Journal of Engineering, Project, and Production Management
2025, 15(3), 0014

Causes of Disputes in Construction: A Fuzzy Synthetic Evaluation

Yasir Alhammadi[1], Afiqah R. Radzi[2], and Rahimi A. Rahman[3,4]

[1]Assistant Professor, Department of Civil Engineering, College of Engineering in Al-Kharj, Prince Sattam Bin Abdulaziz University, Alkharj 11942, Saudi Arabia, Email: y.alhammadi@psau.edu.sa (corresponding author).

[2]Consultant, Research and Development Center, RRB Research Consultants Pte Ltd. 63000 Cyberjaya, Malaysia, Email: afiqah@rrbresearch.com

[3]Associate Professor, Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Kuantan 26300, Malaysia, Email: arahimirahman@umpsa.edu.my

[4]Visiting Professor, Faculty of Graduate Studies, Daffodil International University, Dhaka 1341, Bangladesh.

Project Management
Received December 1, 2024; revised December 20, 2024; January 6, 2025; accepted January 7, 2025
Available online June 30, 2025

Abstract: Construction project disputes are a prevalent issue and require prompt resolution to prevent project delays. Efficient dispute resolution is critical for the success of construction projects. Therefore, the aim of this study is to identify the critical causes of disputes in the Malaysian construction industry and assess their underlying causes. A survey was developed to collect data on the causes of disputes and distributed among industry professionals. The data collected from 125 respondents was analyzed using normalized mean analysis, factor analysis, and fuzzy synthetic evaluation (FSE). Four critical causes of disputes were identified: poorly managed construction processes leading to resource shortages and quality issues, improper contract administration, non-compliance with contractual obligations by either party and errors or omissions in contract documents. Factor analysis revealed that these causes could be categorized into two main components: stakeholder challenges and contractual issues. The FSE results indicated that the components ranged from slightly critical to moderately critical. The study contributes to the literature by categorizing the causes of disputes into stakeholder challenges and contractual issues, offering a structured framework for addressing disputes. The study also highlights the need for improved stakeholder collaboration and contract management to mitigate disputes effectively.

Keywords: Dispute, the construction industry, fuzzy synthetic evaluation, factor analysis.

DOI 10.32738/JEPPM-2025-0014

1. Introduction

Disputes are widely recognized as pervasive issues in the construction industry, frequently resulting in project failures, significant time and financial losses, as well as strained relationships among stakeholders (Kumar Viswanathan et al., 2020). In construction projects, disputes are unavoidable due to the industry's inherent complexities and functions (Naji et al., 2020). Disputes often lead to interruptions to the construction process, causing project delays. When stakeholders are involved in resolving disputes, construction activities may be halted while awaiting a resolution or legal decision. Such delays disrupt schedules and can result in contractual penalties for late completion, further compounding the negative effects on a project. Moreover, disputes can lead to substantial financial burdens (El-Sayegh et al., 2020). Legal fees for dispute resolution, including arbitration or litigation, can be significant (Alrasheed et al., 2023). Additionally, costs may escalate due to project delays because extended timelines often result in increased labor and equipment expenses. Therefore, stakeholders need to identify approaches to address construction project disputes.

Construction projects are inherently complex, involving numerous stakeholders, intricate processes, and varying project dynamics (Zhao et al., 2020). Addressing disputes requires time, effort, and specialized knowledge, which stakeholders may find daunting or difficult to navigate amid the ongoing demands of a project. Furthermore, resolving disputes effectively involves significant financial outlays, including legal fees, mediation costs, and potential compensation payments (Naji et al., 2020). Despite the numerous negative consequences of construction project disputes, stakeholders often fail to address them properly (Illankoon et al., 2022). Frequently, stakeholders seek to resolve disputes quickly without identifying the critical and underlying causes of the disputes. This can lead to temporary solutions that fail to address the root issues, potentially resulting in recurring disputes or unresolved problems. Without a clear understanding of what triggers disputes,

stakeholders may employ ineffective strategies that do not prevent similar issues in the future. Therefore, it is essential to identify and analyze both the critical and underlying causes of disputes to develop more effective and sustainable solutions.

Research on construction project disputes is becoming increasingly prevalent due to their significant impact on the industry. Disputes are considered a major obstacle to the successful completion of construction projects (Lu et al., 2020). Although the existing literature has extensively examined the causes of disputes in the construction industry and different dispute-resolution methods (Illankoon et al., 2022), a significant gap remains in terms of identifying and assessing the critical and underlying causes of disputes, particularly in the Malaysian construction industry. For example, prior works have explored issues like contract management, communication failures, and the role of digital technologies such as BIM (Wang et al., 2023) and blockchain in dispute resolution (Faraji et al., 2024). Moreover, few works have thoroughly analyzed the causes that most frequently trigger disputes (El-Sayegh et al., 2020). Addressing this gap is crucial for developing more effective strategies to prevent disputes before they escalate. By understanding the critical root causes, stakeholders can implement tailored measures that address specific causes, leading to more efficient dispute resolution and improved project outcomes.

Therefore, this study aimed to identify the critical causes of disputes and assess their underlying causes, specifically in Malaysia. To achieve this aim, a survey was developed and distributed to industry professionals, and the collected data was analyzed using normalized mean analysis, factor analysis, and fuzzy synthetic evaluation (FSE). The study addresses the critical causes of disputes in the Malaysian construction industry, identifying the most common and impactful causes. Additionally, the study evaluates how critical each identified cause is in generating disputes, thus offering a better understanding of the severity and impact of different dispute causes. By understanding these root causes, industry professionals can develop better practices and strategies to prevent disputes, leading to smoother project execution and improved outcomes. The insights obtained from the study can help project managers identify potential dispute triggers early in a project's lifecycle, enabling proactive measures to mitigate risks and manage disputes more effectively.

2. Literature Review

2.1. Disputes In The Construction Industry

Disputes in the construction industry encompass disagreements among project stakeholders that occur during different phases, such as planning, execution, or completion (Illankoon et al., 2019). Although conflict and disputes are often used interchangeably, their definitions can vary. Conflict involves divergences in interests, objectives, or priorities among individuals, groups, or organizations (Narh et al., 2015). In contrast, the Institution of Civil Engineers (ICE) characterizes a dispute as emerging when one party asserts a claim that is rejected by another, leading to contested rejection without the claimant's agreement (Shash and Habash, 2021). Disputes can have significant adverse effects on projects, stakeholders, and the overall industry (Silva et al., 2024). These effects include delays in project timelines, increased costs due to legal fees or dispute-resolution processes, and strained relationships between stakeholders. Disputes often lead to disrupted work progress, reduced productivity, and inefficiencies in resource allocation. On a broader scale, unresolved disputes can tarnish the reputations of the stakeholders involved, cause financial instability, and result in project termination (Silva et al., 2024). The cumulative impact of disputes can hinder industry growth and discourage investments in construction projects.

Several works have addressed disputes in the construction industry, illustrating different factors and their impacts. Wang et al. (2023) focused on the adoption of Building Information Modelling (BIM) and its role in mitigating disputes. Their research identified change orders, design flaws, site issues, contractual challenges, payment delays, and project delays as prominent causes of disputes. They highlighted the benefits of BIM, such as improved information management, design optimization, enhanced collaboration, and visual management. Moreover, they proposed a conceptual framework illustrating how BIM can support dispute resolution throughout construction projects. Titus and Ali (2023) explored the relationship between construction disputes and contract incompleteness. Their findings suggested that incomplete contracts contribute significantly to dispute occurrences, emphasizing the importance of thorough contract development and clarity in contractual terms. Gamil and Abd Rahman (2023) examined the impact of poor communication on disputes in the Yemeni construction industry. Their findings revealed that inadequate communication management and channels are critical factors in triggering disputes. They underscored the need for effective communication strategies to mitigate disputes and enhance project outcomes. These works collectively contribute to understanding the multifaceted nature of construction-related disputes, offering insights into their specific causes and mitigating factors like BIM adoption, contract completeness, and communication management.

2.2. Causes Of Disputes And Dispute Resolution

Construction disputes can arise from different factors and causes, as identified by several prior works. Conlin et al. (2002) attributed disputes primarily to payment and budget issues, performance disputes, delays, negligence, quality concerns, and administrative problems among construction stakeholders. Cakmak and Cakmak (2014) classified dispute causes into seven categories: disputes related to owners, contractors, design, contracts, human behavior, and projects, as well as those with external causes. Mahamid (2016) identified several direct causes of disputes, such as delayed progress payments, unreasonable contract durations, change orders, subpar work quality, and labor inefficiencies. Indirect causes included insufficient contractor expertise, poor communication between stakeholders, inadequate planning and scheduling, cash flow problems during construction, and inaccurate estimating techniques. According to Tajul Ariffin and Sutrisna (2010), the primary reasons for disputes encompass incomplete work, subpar craftsmanship, claims for loss and expense extensions of time (EOT), improper contractual relationships, contract termination, design modifications, work variations, challenges linked to construction managers, document clarifications, liability for defects, liquidated damages, and payment disputes.

Dispute resolution in construction encompasses the different methods and processes used to address and settle the disputes and disagreements that occur throughout construction projects. Several methods of dispute resolution are commonly employed in the construction industry. One of these methods is negotiation, the simplest form of dispute resolution, whereby the stakeholders involved in a dispute discuss and negotiate directly to reach a mutually acceptable resolution (Cheung et al., 2020). Negotiation can be informal or formal, depending on the complexity of the issues. Furthermore, mediation is also a method of resolving disputes. This entails a neutral third party (the mediator) facilitating discussions between the stakeholders to help them voluntarily reach an agreement. This process is non-binding, so the stakeholders are not obliged to accept the mediator's suggestions (Abdul-Malak and Senan, 2020). Conversely, arbitration involves submitting a dispute to one or more arbitrators, who will consider the evidence and arguments from both sides before making a binding decision. This process is generally less formal and more streamlined than litigation, resulting in a faster resolution (Abwunza et al., 2021). Litigation also is a method of dispute resolution. It involves resolving disputes through a court system. Construction disputes may be litigated in court if negotiations, mediation, or arbitration fail to resolve the issue.

Moreover, digital construction technologies, such as BIM and blockchain, offer significant potential for enhancing dispute-resolution processes in the construction industry. For example, Faraji et al. (2024) demonstrated that combining Integrated Project Delivery (IPD) practices, which include early stakeholder involvement and multiparty contracts, with advanced technologies like blockchain can significantly enhance dispute management and overall construction process efficiency. Shojaei et al. (2020) explored the implementation of smart contracts by integrating BIM and blockchain technology. The work revealed that blockchain effectively governs construction contracts by automating transaction outcomes and providing a tamper-proof record, which is beneficial for dispute resolution. Despite these advantages, the adoption of such technologies in dispute resolution remains limited. This is largely due to the high implementation costs, the need for specialized skills and training, resistance to change from within the industry, and a lack of standardized protocols for integrating these technologies into existing workflows (Ahmed, 2018; Criminale and Langar, 2017). Therefore, although digital construction technologies like BIM and blockchain have the potential to revolutionize dispute resolution, their broader adoption will require these barriers to be overcome and industry practices to be aligned with technological advancements.

2.3. Knowledge Gap

Although the existing literature has extensively explored the causes of disputes in the construction industry and highlighted different dispute-resolution methods, a significant gap remains in terms of identifying and assessing the critical and underlying causes of disputes specific to the Malaysian construction context. Therefore, this study aimed to bridge this gap by identifying the critical causes of disputes in the Malaysian construction industry and assessing their underlying causes, providing valuable insights for stakeholders seeking to manage and mitigate disputes in construction projects.

3. Methodology

3.1. Survey Development

A survey was used to gather opinions on the critical causes of disputes in the construction industry. The survey approach was chosen because it is cost-effective and allows data to be collected from a large number of respondents in a relatively short period (Radzi et al., 2024). This method is commonly used in construction management research to solicit expert opinions on specific topics (Radzi et al., 2022; Al-Mohammad et al., 2023). Figure 1 shows the methodology followed during this study.

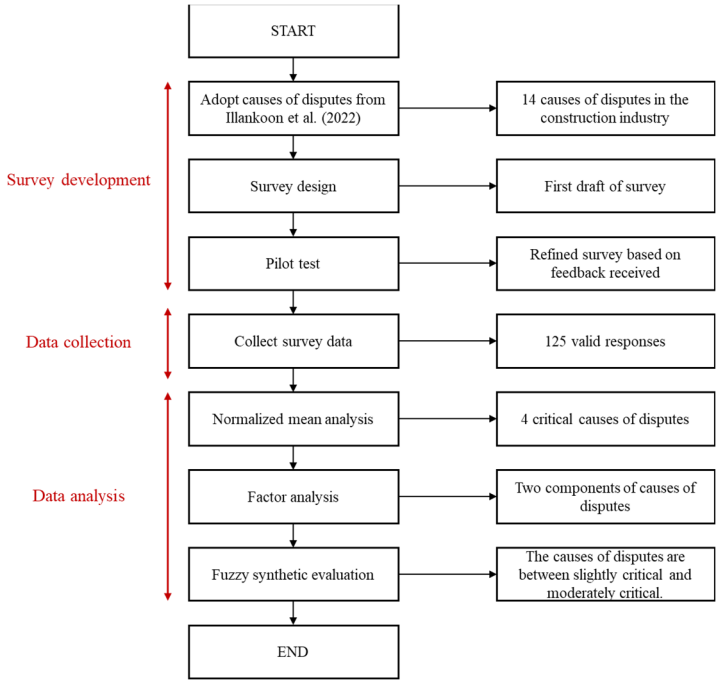

Fig. 1. Research methodology

Accordingly, this study adopted the list of causes of construction project disputes provided by Illankoon et al. (2022). Their research was conducted in Sri Lanka, whereas the current study focuses on the construction industry in Malaysia. Different regions have unique cultural, regulatory, and operational contexts. Thus, this study helps identify region-specific causes that might not be apparent in other contexts, leading to a more nuanced understanding of the issue and how to develop tailored solutions. Table 1 lists the 14 causes of disputes that were adopted from Illankoon et al. (2022).

Table 1. Causes of disputes

Code	Causes of disputes
C1	Failure to properly administer the contract
C2	Error or omissions in contract documents
C3	Incomplete design information or Employer requirement
C4	Failure to understand or comply with its contractual obligations by either party
C5	Poorly managed construction process leading to a shortage of resources and quality issues
C6	Diverse interpretation of contract terms
C7	Inadequate risk identification/allocation
C8	Lack of cooperation and trust among parties
C9	Opportunistic behavior of project parties
C10	The reluctance of project participants to deal with changes
C11	Lack of experience in construction practices and management
C12	Lack of interpersonal skills among professionals
C13	Conflicting goals and objectives of project parties
C14	External uncertain factors such as weather conditions or environmental regulations

The survey development began by clearly displaying the study's objective and the author's contact details on the front page. The survey was organized into two sections. The purpose of the first section was to obtain background and organizational information from the respondents, which was an essential step in assessing the reliability of their answers. In the second section, the respondents were asked to rate the criticality of each of the 14 causes of disputes using a five-point Likert scale, which ranged from "not critical" to "extremely critical". The five-point Likert scale was selected for its ease of use and capacity to yield concise, useful insights (Radzi et al., 2022).

A pilot test was conducted with three professors and three industry professionals to ensure the survey's accuracy and clarity. The pilot test aimed to eliminate unclear language and confirm that technical terms were being used correctly. It also assisted in locating any problems with the survey instrumentation and design. Cooper and Schindler (2014) noted that the feedback from a pilot test is essential for improving a survey's quality and determining how long it would take to complete. The survey was refined based on the constructive feedback, resulting in a reliable data collection instrument.

3.2. Data Collection

The target population for this study comprised industry professionals with experience in Malaysian construction, including key stakeholders such as clients, contractors, and consultants. To obtain a representative sample, a minimum of 30 respondents is considered sufficient for statistical analysis and drawing meaningful conclusions (Ott and Longnecker, 2015). Given the lack of a comprehensive sampling frame, a non-probability sampling method was used (Omer et al., 2024), which is appropriate when a completely random approach is impractical. Respondents were selected based on their willingness to participate, with a purposive sampling technique followed to ensure a valid and efficient sample size (Patton, 2001).

Table 2. Respondents profile

Characteristics	Categories	Frequency	Percentage (%)
Highest academic qualification	Diploma	31	24.8
	Bachelor's Degree	84	67.2
	Master's Degree	7	5.6
	High School Certification	3	2.4
Years of experience in the construction industry	Less than 2 years	63	50.4
	2-5 years	39	31.2
	6-9 years	10	8
	More than 10 years	13	10.4
Number of construction projects involved	1 project	22	17.6
	2-5 projects	64	51.2
	6-9 projects	13	10.4
	More than 10 projects	26	20.8
Type of organizations	Clients	18	14.4
	Contractors	76	60.8
	Consultants	31	24.8

Table 2 outlines the demographic details of the 125 respondents, categorized by their highest academic qualification, years of experience in the construction industry, number of projects participated in, and organizational affiliation. According to the table, most respondents (67.2%) possess a bachelor's degree. Furthermore, approximately half of the respondents had accumulated at least two years of experience in construction projects, and 82.4% had been involved in two or more projects. Regarding organizational roles, contractors represent the largest segment of respondents at 60.8%, followed by consultants

at 24.8% and clients at 14.4%. These findings provide a snapshot of the educational backgrounds, industry experience, project involvement, and organizational affiliations of these respondents, offering valuable insights into the composition of the surveyed professional group within the Malaysian construction industry.

3.3. Methods

3.3.1. Data reliability

Reliability analysis was conducted prior to data analysis to evaluate the consistency and dependability of the survey instrument used. Cronbach's alpha (α) was employed, which is a widely accepted method for assessing the internal consistency of questionnaire items. According to Nunnally (1994), a minimum α value of 0.70 is generally considered acceptable for ensuring the reliability of a scale. In this study, the overall α value obtained was 0.953. This high value suggested a strong internal consistency among the variables measured by the survey instrument. The five-point Likert scale was found to be reliable at a significance level of 5% across all 14 causes examined. Therefore, based on the high α value of 0.953, the data collected from the survey was considered reliable and suitable for further analysis.

The data was then screened using the two-standard deviation approach to find any outliers (Radzi et al., 2022). The intervals between two standard deviations are calculated using this method. As a result, the means, standard deviations, and two standard deviation intervals of the causes were determined. Poorly managed construction processes leading to resource shortages and quality issues (C5) was deemed an outlier based on the calculation because it fell outside the two standard deviation intervals (3.157 and 2.611). Nevertheless, due to its apparent significance as a contributing cause to construction disputes, C5 was not removed. One of the most well-known main causes of construction management disputes is poorly managed construction processes that result in resource constraints and quality difficulties (El-Sayegh et al., 2020). Therefore, the impact of this event was deemed substantial enough to warrant attention, even if it was a statistical outlier.

3.3.2. Normalized mean analysis

Normalized mean analysis was employed to rank causes based on the survey data. This approach involved calculating the means and standard deviations of the responses to assess the relative importance of each cause (Radzi et al., 2022). Lower standard deviations indicate higher consistency among responses, suggesting the greater reliability of the mean score. When causes had identical mean values, those with the lowest standard deviation were prioritized, reflecting more consistent perceptions among the respondents. Normalized mean values were then calculated to identify critical causes. Causes with normalized mean values exceeding 0.50 were considered critical (Ma et al., 2020).

Table 3. Steps of FSE

Steps	Explanations
Step 1: Weightings for each cause of dispute	Weightings for each cause of dispute were determined using equation (1). $W_i = \frac{M_i}{\sum_{i=1}^{n} M_i},\ 0 \le wi \le 1, 0 \le i \le 1 \ldots (1)$ Where: W_i = weighting for the *i*th cause of dispute; M_i = mean score of the *i*th cause of dispute; $\sum M_i$ = summation of the mean score of all causes of disputes.
Step 2: Components' MF	MF for the causes of disputes are generated by FSE using grading options. E = (1, 2, 3, 4, 5) represents the five-point Likert grading scale, which goes from 1 (very low) to 5 (very high). Equation (2) was used to determine the MF of each cause of dispute based on the survey results. $MFu_{in} = \frac{x_{1u_{in}}}{E_1} + \frac{x_{2u_{in}}}{E_2} + \frac{x_{3u_{in}}}{E_3} + \frac{x_{4u_{in}}}{E_4} + \frac{x_{5u_{in}}}{E_5} \ldots (2)$ Where: u_{in} = causes of disputes; MFu_{in} = MF of a given cause of dispute; $x_{ju_{in}}$ (j = 1, 2, 3, 4, 5) = percentage of respondents who were rated *j* for a specific cause of dispute; $\frac{x_{ju_{in}}}{E_1}$ = relationship between $x_{ju_{in}}$and its grade alternative; + = notation in a fuzzy set. The MF of a particular cause of dispute could be shown as follows using Equation (3):$MFu_{in} = x_{1u_{in}} + x_{2u_{in}} + x_{3u_{in}} + x_{4u_{in}} + x_{5u_{in}} \ldots (3)$ Equation (4) is used to process and can be applied when numerous components are examined and the weight difference between them is low. $M(\cdot,\oplus)b_j = \min\left(1, \sum w_i \times r_{ij}\right) min = 1 \forall b_j \in B \ldots (4)$ Where: w_i = weightings of each cause of dispute; r_{ij} = MF of each cause of dispute; $\oplus$: sum of the weighting and MF
Step 3: OCL	The OCL of causes of disputes was computed using Equation (5). $\mathrm{OCL} = \Sigma \mathrm{n_{i=1}} (\mathrm{W} \times \mathrm{R_i}) \times \mathrm{L} \ldots (5)$ Where: W = weightings; R = degree of the MF; L = linguistic variables (1-very low, 2-low, 3-neutral, 4-high, 5-very high)

3.3.3. Factor analysis

This study also employed factor analysis to streamline the complex set of interrelated variables into more coherent and manageable components (Norusis, 2008). To ensure the adequacy of the sample size for factor analysis, a crucial ratio of 8.93 (125/14) was computed. This exceeded the recommended threshold of 5.00 (Gorsuch, 2014), thus affirming the sample size adequacy. Two tests were conducted to validate the suitability of the data for factor analysis. Firstly, the Kaiser-Meyer-

Olkin (KMO) test was used, whereby a value greater than 0.50 is generally considered acceptable, comparing squared correlations between variables to squared partial correlations. Secondly, Bartlett's test of sphericity evaluated the adequacy of the correlation matrix for factor analysis, ensuring significant interrelationships among variables (Pallant, 2020). Principal Component Analysis (PCA) was employed for factor extraction, with variables that had eigenvalues exceeding one retained, which would indicate their substantial contributions to the principal components. Varimax rotation was applied to enhance interpretability, with variables with factor loadings above 0.50 regarded as significant (Osborne, 2015).

Moreover, to determine the relative contribution of each component to the overall causes of disputes, a set of steps was taken. First, the total means of causes within each component were computed. These means were then aggregated for each component. Next, each component's aggregated mean was divided by the sum of all the component means, multiplied by 100 to derive the percentage contribution of each component to the overall causes.

3.3.4. Fuzzy synthetic evaluation (FSE)

Finally, the criticality of each cause of dispute and its components was evaluated using FSE. FSE has been used to deliver thorough assessments in construction project management research (Dahalan et al., 2023). The steps involved in FSE include calculating the weightings for each dispute cause, determining the membership functions (MF) for each component, and calculating the overall criticality level (OCL), as outlined in Table 3.

4. Results

4.1. Normalized Mean Analysis

Table 4 displays the results of the normalized mean analysis, indicating that the mean values of the causes ranged from 2.648 to 3.184. Causes of disputes with normalized mean values exceeding 0.50 were deemed critical. Four causes surpass this threshold: poorly managed construction processes leading to resource shortages and quality issues (C5), failure to properly administer a contract (C1), failure to understand or comply with contractual obligations by either party (C4), and errors or omissions in contract documents (C2). These findings underscore the significance of addressing these issues in order to mitigate potential disputes and enhance project performance.

Table 4. Result of normalized mean analysis

Code	Causes of disputes	Mean	SD	NV
C5	Poorly managed construction process leading to a shortage of resources and quality issues	3.184	1.346	1.000*
C1	Failure to properly administer the contract	3.056	1.227	0.761*
C4	Failure to understand or comply with its contractual obligations by either party	3.000	1.362	0.657*
C2	Error or omissions in contract documents	2.936	1.183	0.537*
C11	Lack of experience in construction practices and management	2.896	1.263	0.463
C3	Incomplete design information or Employer requirement	2.896	1.294	0.463
C10	The reluctance of project participants to deal with changes	2.888	1.239	0.448
C8	Lack of cooperation and trust among parties	2.872	1.225	0.418
C7	Inadequate risk identification/allocation	2.848	1.238	0.373
C6	Diverse interpretation of contract terms	2.840	1.201	0.358
C9	Opportunistic behavior of project parties	2.840	1.214	0.358
C12	Lack of interpersonal skills among professionals	2.752	1.229	0.194
C13	Conflicting goals and objectives of project parties	2.720	1.255	0.134
C14	External uncertain factors such as weather conditions or environmental regulations	2.648	1.138	0.000

Notes: SD = standard deviation; NV = normalized value; * = critical causes of disputes

4.2. Factor Analysis

The KMO value for all 14 causes of disputes stands at 0.919, exceeding the minimum threshold of 0.50 and indicating strong sample adequacy. In contrast, a significant result of 0.000 was obtained from Bartlett's test of sphericity, indicating that the dataset is not an identity matrix and supporting that meaningful correlations existed between variables. As such, the information was considered appropriate for further analysis. Of the fourteen causes, only twelve were successfully loaded into two underlying components, as shown in Table 5, with factor loadings greater than 0.50 for each cause. These two components account for 70.180% of the variance. They were named stakeholder challenges and contractual issues. These underlying components highlight the causes influencing disputes in construction projects, paving the way for targeted interventions to mitigate risks and enhance project outcomes.

Figure 2 illustrates the percentage of each component contributing to the overall causes of disputes in the construction industry. The results indicate that "stakeholder challenges" account for 49%, and "contractual issues" contribute approximately 37%. Additionally, two causes with loading values of less than 0.50, identified as C4 and C7, were included in the calculation and grouped under "others". Collectively, these causes contribute 14% to the overall causes of disputes in the construction industry.

Table 5. Result of factor analysis

Components	Code	Causes of disputes	Factor loadings	Variance explained
Stakeholder challenges (SC)	C12	Lack of interpersonal skills among professionals	0.796	36.933
	C13	Conflicting goals and objectives of project parties	0.778	
	C8	Lack of cooperation and trust among parties	0.768	
	C10	The reluctance of project participants to deal with changes	0.764	
	C14	External uncertain factors such as weather conditions or environmental regulations	0.685	
	C9	Opportunistic behavior of project parties	0.661	
	C11	Lack of experience in construction practices and management	0.636	
Contractual issues (CI)	C2	Error or omissions in contract documents	0.883	33.247
	C1	Failure to properly administer the contract	0.821	
	C5	Poorly managed construction process leading to a shortage of resources and quality issues resources and quality issues	0.750	
	C3	Incomplete design information or employer requirement	0.745	
	C6	Diverse interpretation of contract terms	0.671	

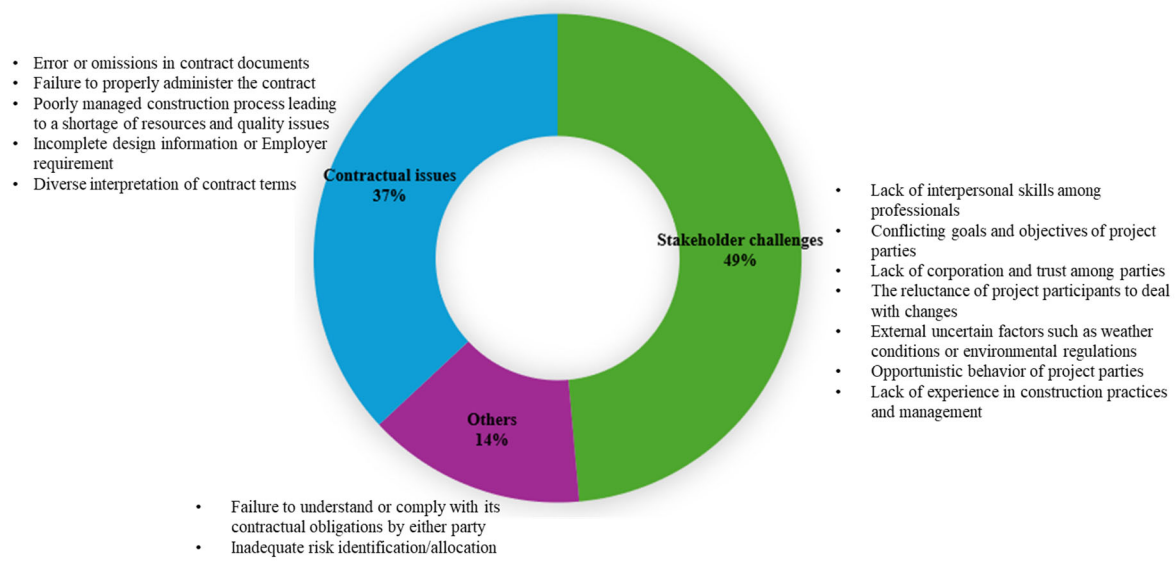

Fig. 2. Percentages of each component

Table 6. Description of causes input variables

Code	Mean	Standard deviation	Normalized value	Code for index system	Overall rank	Component rank	Total mean	Component weight
SC	-	-	-	u_{sc}	-	-	19.616	0.568
C12	2.752	1.229	0.194	u_{sc1}	10	1	-	-
C13	2.720	1.255	0.134	u_{sc2}	11	2	-	-
C8	2.872	1.225	0.418	u_{sc3}	7	3	-	-
C10	2.888	1.239	0.448	u_{sc4}	6	4	-	-
C14	2.648	1.138	0.000	u_{sc5}	12	5	-	-
C9	2.840	1.214	0.358	u_{sc6}	9	6	-	-
C11	2.896	1.263	0.463	u_{sc7}	4	7	-	-
CI	-	-	-	u_{ci}	-	-	14.912	0.432
C2	2.936	1.183	0.537	u_{ci1}	3	1	-	-
C1	3.056	1.227	0.761	u_{ci2}	2	2	-	-
C5	3.184	1.346	1.000	u_{ci3}	1	3	-	-
C3	2.896	1.294	0.463	u_{ci4}	5	4	-	-
C6	2.840	1.201	0.358	u_{ci5}	8	5	-	-
						Total	34.528	1.000

4.3. FSE

Two components (SC and CI) are the foundation for measuring the criticality of the causes of disputes. The components were expressed as the first-level index system and as $U = (u_1, u_2, u_3, u_m)$, where U represents the universal set in a fuzzy set environment, and u_1, u_2, u_3, u_m represent the components. Each component, defined as the second-level system, consists of several causes of disputes. Therefore, the set U_{cd} can be expressed as ($U_{cd} = u_{sc}, u_{ci}$). The descriptive statistics of the input variables are presented in Table 6.

The set of values in a defined MF ranges between 0 and 1, and the summation of all the values must equate to 1. The MFs and the respective weightings for a particular cause of disputes were processed to derive the MF of a component. The MFs for the individual variables (causes of disputes) are presented in the Table below (see Level 3). The weightings of all the variables and their respective components are presented in Table 7.

Table 7. Result from the fuzzy synthetic evaluation

Code	Level	Mean	Weightings	MF value
Overall	1	-	-	0.162, 0.232, 0.281, 0.210, 0.115
SC	2	-	0.568	0.169, 0.250, 0.297, 0.177, 0.108
C12	3	2.752	0.140	0.168, 0.280, 0.304, 0.128, 0.120
C13	3	2.720	0.139	0.200, 0.256, 0.272, 0.168, 0.104
C8	3	2.872	0.146	0.160, 0.232, 0.288, 0.216, 0.104
C10	3	2.888	0.147	0.168, 0.200, 0.328, 0.184, 0.120
C14	3	2.648	0.135	0.184, 0.264, 0.336, 0.152, 0.064
C9	3	2.840	0.145	0.160, 0.248, 0.280, 0.216, 0.096
C11	3	2.896	0.148	0.144, 0.272, 0.272, 0.168, 0.144
CI	2	-	0.432	0.153, 0.209, 0.260, 0.253, 0.125
C2	3	2.936	0.197	0.144, 0.208, 0.304, 0.256, 0.088
C1	3	3.056	0.205	0.136, 0.184, 0.296, 0.256, 0.128
C5	3	3.184	0.214	0.152, 0.176, 0.200, 0.280, 0.192
C3	3	2.896	0.194	0.176, 0.240, 0.216, 0.248, 0.120
C6	3	2.840	0.190	0.160, 0.240, 0.288, 0.224, 0.088

Table 8 presents the criticality level for the components. Based on the calculation, the OCL of 2.884 suggests that the causes of disputes are perceived as slightly critical. Contractual issues, in contrast, have the highest criticality level (2.987). Stakeholder challenges were next (2.805). The component criticality index ranges from "slightly critical" to "moderately critical".

Table 8. Criticality index of the components

No.	Components	Components code	Index
1	Stakeholder challenges	SC	2.805
2	Contractual issues	CI	2.987

5. Discussion

5.1. Stakeholder Challenges

One of the components identified by the factor analysis was stakeholder challenges. This accounts for 36.933 of the total variance in the factor analysis and consists of eight causes of disputes. Effective communication is crucial for both collaboration and dispute resolution. A lack of interpersonal skills among professionals can lead to misunderstandings and disputes (Gamil and Abd Rahman, 2023). To address this, stakeholders should invest in training programs that enhance communication, negotiation, and dispute resolution skills. This would improve team interactions and reduce the potential for disputes. Conflicting goals and objectives among project stakeholders often result in disagreements. Misaligned goals can hinder collaboration and delay projects (Manata et al., 2021). Therefore, stakeholders can mitigate this issue by establishing clear, aligned objectives from the project's outset. In addition, regular meetings to review and adjust goals can help ensure that all stakeholders remain focused on the common objectives. The lack of cooperation and trust among stakeholders is another significant issue in the construction industry. Trust is fundamental to effective collaboration and dispute resolution (Li et al., 2021). Building trust through team-building activities, transparent communication, and honoring commitments can improve stakeholder cooperation, thereby reducing the likelihood of disputes. Besides, a reluctance to deal with change is a common problem in the dynamic construction industry (Lines et al., 2015). Therefore, stakeholders should foster a culture that embraces change by training staff on change management and involving all stakeholders in the change process.

Furthermore, external uncertain factors, such as weather conditions or environmental regulations, can disrupt project timelines and plans, leading to delays and cost overruns (Schuldt et al., 2021). Thus, stakeholders should conduct thorough risk assessments and develop contingency plans to manage and mitigate the impacts of these uncertainties, thus minimizing disruptions and the associated disputes. Another cause of disputes is the opportunistic behavior of project stakeholders, whereby individuals act in their self-interest at the expense of the project, undermining trust and collaboration. To deter such behavior, stakeholders should establish clear contracts with defined roles, responsibilities, and penalties for unethical actions. Besides, encouraging ethical behavior through codes of conduct and regular compliance checks is also essential. Finally, a lack of experience in construction practices and management can result in mistakes and poor decisions (Yap et al., 2022),

contributing to disputes. Therefore, stakeholders should ensure their teams have the necessary experience and qualifications. Providing ongoing training and mentoring for less-experienced team members can help bridge the knowledge gap and improve overall project performance.

5.2. Contractual Issues

Another component identified through factor analysis was contractual issues. This accounts for 33.247 of the total variance in the factor analysis and consists of four causes of disputes. Errors or omissions in contract documents refer to inaccuracies, missing details, or ambiguities in the contractual agreements governing the project, resulting in misunderstandings, delays, and cost overruns (Titus and Ali, 2023). Thus, thorough reviews of contract documents before finalization, with stakeholders involved in the review process, are essential for addressing errors or omissions in contract documents. Moreover, a failure to properly administer contracts might lead to breaches and disputes. Therefore, the crucial measures are appointing qualified contract administrators to oversee contract execution, monitoring compliance with contract terms and conditions, and establishing mechanisms for resolving disputes promptly.

Poorly managed construction processes might exacerbate resource shortages and quality deficiencies, further contributing to disputes. Therefore, it is vital to first ensure proper resource planning and allocation and, second, implement quality control measures. Furthermore, incomplete design information or ambiguous employer requirements can lead to misinterpretations and disagreements among project stakeholders, disrupting a project's progress. Thus, close collaboration with designers and employers to clarify requirements and ensure that the design information is complete and accurate before commencing construction can help address the issues of incomplete design information or employer requirements. Another cause of disputes is diverse interpretations of contract terms, which can result in disagreements, disputes, and delays, thus hindering project progress (Gilson et al., 2014). To address this, stakeholders should engage in open communication and negotiation to clarify contract terms, seeking legal advice to resolve any disputes arising from diverse interpretations. Moreover, clear communication channels can be established, which are essential for addressing diverse interpretations of contract terms.

5.3. Comparison With Prior Works

A comparison of the results of this study with prior findings reveals similarities and differences between the causes of disputes in construction projects. Table 9 provides a detailed comparison of works exploring the causes of construction disputes that have been conducted in Malaysia (this study), Pakistan (Farooqui et al., 2014), Jordan (Matarneh, 2024), the United Arab Emirates (UAE) (El-Sayegh et al., 2020), and Vietnam (Vo et al., 2020). The findings reveal that several common causes of disputes recur across the different regions, including errors or omissions in contract documents, incomplete design information, a lack of experience in construction practices and management, inadequate risk identification and allocation, and external uncertainties like weather conditions or regulatory changes. However, some causes, such as the reluctance of project participants to manage changes, opportunistic behavior, and conflicting goals among project parties, were not identified in prior works and appear to be unique findings from this study. These differences underscore, first, the unique challenges posed by examining regional contexts and, second, the shared difficulties faced in managing construction disputes. Overall, the comparative analysis highlights the importance of understanding both universal and localized factors that contribute to disputes in the construction industry.

Table 9. Comparison with prior works

Causes of disputes/ Countries	Malaysia (this study)	Pakistan[1]	Jordan[2]	UAE[3]	Vietnam[4]
Poorly managed construction process leading to a shortage of resources and quality issues	/	/	/	/	/
Failure to properly administer the contract	/	/	/	-	/
Failure to understand or comply with its contractual obligations by either party	/	/	/	-	-
Error or omissions in contract documents	/	-	/	/	/
Lack of experience in construction practices and management	/	/	-	/	/
Incomplete design information or employer requirement	/	-	/	-	/
The reluctance of project participants to deal with changes	/	-	-	-	-
Lack of cooperation and trust among parties	/	/	/	/	/
Inadequate risk identification/allocation	/	/	-	-	-
Diverse interpretation of contract terms	/	/	-	-	-
Opportunistic behavior of project parties	/	-	-	-	-
Lack of interpersonal skills among professionals	/	/	-	-	/
Conflicting goals and objectives of project parties	/	-	-	-	-
External uncertain factors such as weather conditions or environmental regulations	/	-	-	/	/

Notes: [1] = Farooqui et al. (2014); [2] = Matarneh (2024); [3] = El-Sayegh et al. (2020); [4] = Vo et al. (2020)

5.4. Implications

The findings of this study have theoretical and practical implications. The study provides a significant theoretical contribution by categorizing dispute causes into two main components: stakeholder challenges and contractual issues. This structured framework enhances the understanding of dispute dynamics in construction projects and forms a foundation for future research. Additionally, integrating normalized mean analysis, factor analysis, and FSE offers a robust methodological approach that researchers might adopt or refine when analyzing similar issues.

In terms of practical implications, the results highlight the importance of robust contract management practices and effective resource management to prevent issues—like shortages and quality defects—that can lead to disputes. Contractors should prioritize clear communication and precise documentation to reduce risks. Project managers can apply these insights to enhance risk mitigation strategies, focusing on the early detection and resolution of compliance issues and optimizing processes in areas prone to errors, such as contract documentation and administration. Policymakers, in contrast, could leverage these findings to refine regulatory guidelines, promoting standardized practices for contract management and dispute prevention. Additionally, they could support educational initiatives that train industry professionals on best practices in compliance, contract management, and dispute resolution. Addressing these key areas will contribute to reducing disputes and improving project outcomes across the construction industry.

6. Conclusion

This study investigates the causes of disputes, employing a comprehensive approach that includes normalized mean analysis, factor analysis, and fuzzy synthetic evaluation (FSE). From the analysis, four critical causes of disputes were identified: poorly managed construction processes leading to resource shortages and quality issues; inadequate contract administration; failure to understand or comply with contractual obligations by involved stakeholders; and errors or omissions in contract documents. Factor analysis revealed that these causes can be categorized into two primary components: stakeholder challenges and contractual issues. Additionally, the FSE results indicated that the components ranged from slightly critical to moderately critical in their impact. Understanding these causes is essential for construction professionals as it facilitates the development of improved dispute mitigation practices and strategies. Contractors can enhance contract management and resource allocation. Project managers can focus on risk mitigation and process optimization. Policymakers can also use these insights to refine regulatory guidelines and promote best practices through training initiatives. Addressing these underlying issues can lead to smoother project execution, reduced disputes, and more favorable project outcomes across the construction industry.

The study has several limitations that should be considered in future research. Firstly, the sample size of 125 respondents may not fully represent the entire diversity of the construction industry. Future research could enhance representativeness by increasing the sample size and including a broader range of industries and geographical regions. Secondly, the findings may not be generalizable to other regions with different construction practices, regulations, and cultural contexts. Comparative research across different countries or regions could provide insights into how different factors influence the causes of disputes in construction projects. Lastly, although this study used normalized mean analysis, factor analysis, and FSE, other advanced analytical techniques like machine learning algorithms or predictive modeling could offer additional insights or validation. Future researchers could apply these methods to uncover deeper patterns and relationships in dispute causes. Furthermore, to advance the findings of this study, future research should explore practical strategies for addressing stakeholder and contractual issues in greater detail. More specifically, future research should investigate how technology such as BIM and blockchain can be effectively leveraged to resolve these issues. By examining the role of digital construction technologies in managing disputes and improving construction processes, researchers can provide actionable solutions that go beyond the existing literature and contribute to more innovative and practical dispute-resolution strategies.

Acknowledgments

The authors are thankful to the industry professionals who contributed to this study, as well as the editors and anonymous reviewers whose insightful remarks helped enhance the quality of this paper.

Author Contributions

Yasir Alhammadi contributes to the writing of the original draft and funding acquisition. Afiqah R. Radzi contributes to the data analysis and writing of the original draft. Rahimi A. Rahman contributes to the development of the idea, conceptualization, methodology, data collection, validation, supervision, project administration, and manuscript editing. All authors have read and agreed with the manuscript before its submission and publication.

Funding

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work through the project number (PSAU/2024/01/99523).

Institutional Review Board Statement

Not applicable.

References

Abdul-Malak, M. A. U., and Senan, M. H. (2020). Operational mechanisms and effectiveness of adjudication as a key step in construction dispute resolution. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 12(1), 04519051.

Abwunza, A. A., Peter, T. K., and Muigua, K. (2021). Explaining the effectiveness of construction arbitration: An organizational justice perspective. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 13(3), 04521017.

Ahmed, S. (2018). Barriers to implementation of building information modeling (BIM) to the construction industry: a review. *Journal of Civil Engineering and Construction*, 7(2), 107-113.

Al-Mohammad, M. S., Haron, A. T., Rahman, R. A., & Alhammadi, Y. (2023). Factors affecting BIM implementation in Saudi Arabia: A critical analysis. *International Journal of Building Pathology and Adaptation*.

Alrasheed, K. A., Soliman, E., and AlMesbah, F. E. (2023). Dispute classification in construction projects based on litigation cases. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 15(3), 04523013.

Cakmak, E., and Cakmak, P. I. (2014). An analysis of causes of disputes in the construction industry using analytical network process. *Procedia-Social and Behavioral Sciences*, 109, 183-187.

Cheung, S. O., Li, K., and Chow, O. Y. (2020). Reactive devaluation as a psychological impediment to construction dispute negotiation. *Journal of Management in Engineering*, 36(4), 04020025.

Conlin, J. T., Langford, D. A., and Kennedy, P. (2002). The relationship between construction procurement strategies and construction contract disputes. *In The Organization and Management of Construction* (pp. 360-371). Routledge.

Cooper, D. R., and Schindler, P. (2014). Business research methods. Mcgraw-hill.

Criminale, A., and Langar, S. (2017, April). Challenges with BIM implementation: a review of literature. In 53rd *ASC annual international conference proceedings* (pp. 329-335).

Dahalan, N. H., Rahman, R. A., Ahmad, S. W., & Che Ibrahim, C. K. I. (2023). Public monitoring of environmental management plan implementation in road construction projects: Key performance indicators. *Journal of Engineering, Design and Technology*.

El-Sayegh, S., Ahmad, I., Aljanabi, M., Herzallah, R., Metry, S., and El-Ashwal, O. (2020). Construction disputes in the UAE: Causes and resolution methods. *Buildings*, 10(10), 171.

Faraji, A., Homayoon Arya, S., Ghasemi, E., Rashidi, M., Perera, S., Tam, V., and Rahnamayiezekavat, P. (2024). A conceptual framework of decentralized blockchain integrated system based on building information modeling to steering digital administration of disputes in the IPD contracts. *Construction Innovation*, 24(1), 384-406.

Farooqui, R. U., Azhar, S., and Umer, M. (2014, March). Key causes of disputes in the Pakistani construction industry-assessment of trends from the viewpoint of contractors. *In 50th ASC Annual International Conference* (pp. 1-8).

Gamil, Y., and Abd Rahman, I. (2023). Impact of poor communication on dispute occurrence in the construction industry: a preliminary exploratory study of Yemen construction industry. *International Journal of Construction Management*, 23(16), 2729-2735.

Gilson, R. J., Sabel, C. F., and Scott, R. E. (2014). Text and context: contract interpretation as contract design. Cornell L. Rev., 100, 23.

Gorsuch, R. L. (2014). Factor analysis: Classic edition. Routledge.

Illankoon, I. M. C. S., Tam, V. W., Le, K. N., and Ranadewa, K. A. T. O. (2022). Causes of disputes, factors affecting dispute resolution and effective alternative dispute resolution for Sri Lankan construction industry. *International Journal of Construction Management*, 22(2), 218-228.

Kumar Viswanathan, S., Panwar, A., Kar, S., Lavingiya, R., and Jha, K. N. (2020). Causal modeling of disputes in construction projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 12(4), 04520035.

Li, B., Gao, Y., Zhang, S., and Wang, C. (2021). Understanding the effects of trust and conflict event criticality on conflict resolution behavior in construction projects: Mediating role of social motives. *Journal of Management in Engineering*, 37(6), 04021066.

Lines, B. C., Sullivan, K. T., Smithwick, J. B., and Mischung, J. (2015). Overcoming resistance to change in engineering and construction: Change management factors for owner organizations. *International Journal of Project Management*, 33(5), 1170-1179.

Lu, C., Yu, Z., Wang, X., and Hong, Y. (2020). Empirical study on the obstacles to the success of joint ventures in construction projects. *Advances in Civil Engineering*, 2020(1), 1748198.

Ma, X., Chan, A. P., Li, Y., Zhang, B., and Xiong, F. (2020). Critical strategies for enhancing BIM implementation in AEC projects: perspectives from Chinese practitioners. *Journal of Construction Engineering and Management*, 146(2), 05019019.

Mahamid, I. (2016). Micro and macro level of dispute causes in residential building projects: Studies of Saudi Arabia. *Journal of King Saud University-Engineering Sciences*, 28(1), 12-20.

Manata, B., Garcia, A. J., Mollaoglu, S., and Miller, V. D. (2021). The effect of commitment differentiation on integrated project delivery team dynamics: The critical roles of goal alignment, communication behaviors, and decision quality. *International Journal of Project Management*, 39(3), 259-269.

Matarneh, S. (2024). Construction Disputes Causes and Resolution Methods: A Case Study from a Developing Country. *Journal of Construction in Developing Countries*, 29(1), 139-161.

Naji, K. K., Mansour, M. M., and Gunduz, M. (2020). Methods for modeling and evaluating construction disputes: A critical review. *IEEE Access*, 8, 45641-45652.

Narh, O. C., Owusu, E. E., Oduro-Apeatu, K., and Narh, T. W. J. (2015). An exploratory study of professional conflicts and disputes within the construction industry. *International Journal of Managerial Studies and Research*, 3(12), 44-65.

Norusis, M. (2008). SPSS 16.0 statistical procedures companion. Prentice Hall Press.

Nunnally, J. (1994). Psychometric theory. (No Title).

Omer, M. M., Moyo, T., Alias, A. R., & Rahman, R. A. (2024). Development of workplace well-being indexes at construction sites. *Journal of Engineering, Design and Technology*.

Osborne, J. W. (2015). What is rotating in exploratory factor analysis?. Practical Assessment, Research, and Evaluation, 20(1).
Ott, R. L., and M. T. Longnecker. 2015. An introduction to statistical methods and data analysis. Scarborough, ON, Canada: Nelson Education.
Pallant, J. (2020). SPSS survival manual: A step by step guide to data analysis using IBM SPSS. Routledge.
Patton, M. Q. (2001). Qualitative research and evaluation components. Thousand Oaks, CA: SAGE.
Radzi, A. R., KS, A., Alias, A. R., Algahtany, M., & Rahman, R. A. (2024). Modeling the factors affecting workplace well-being at construction sites: a cross-regional multigroup analysis. *Journal of Engineering, Design and Technology*.
Radzi, A. R., Rahman, R. A., Doh, S. I., and Esa, M. (2022). Construction readiness for highway projects: key decision criteria. *Journal of Construction Engineering and Management*, 148(2), 04021196.
Schuldt, S. J., Nicholson, M. R., Adams, Y. A., and Delorit, J. D. (2021). Weather-related construction delays in a changing climate: a systematic state-of-the-art review. *Sustainability*, 13(5), 2861.
Shash, A. A., and Habash, S. I. (2021). Disputes in construction industry: Owners and contractors' views on causes and remedies. *J. Eng. Project Prod. Manage*, 11(1), 37-51.
Shojaei, A., Flood, I., Moud, H. I., Hatami, M., and Zhang, X. (2020). An implementation of smart contracts by integrating BIM and blockchain. *In Proceedings of the Future Technologies Conference (FTC) 2019*: Volume 2 (pp. 519-527). Springer International Publishing.
Silva, P. M., Domingo, N., and Ameer Ali, N. A. N. (2024). Causes of disputes in the construction industry–a systematic literature review. *Journal of Financial Management of Property and Construction*, 29(2), 193-210.
Tajul Ariffin, H. L., and Sutrisna, M. (2010). Developing a framework to minimize the occurrence of construction conflict and disputes in different procurement strategies: An initial review of literature.
Titus, O. O., and Ali, K. N. (2023). Construction dispute and contract incompleteness in Nigeria construction industry. *Ain Shams Engineering Journal*, 14(10), 102153.
Vo, K. D., Nguyen, P. T., and Nguyen, Q. L. H. T. T. (2020). Disputes in managing projects: A case study of construction industry in Vietnam. *The Journal of Asian Finance, Economics and Business*, 7(8), 635-644.
Wang, J., Zhang, S., Fenn, P., Luo, X., Liu, Y., and Zhao, L. (2023). Adopting BIM to facilitate dispute management in the construction industry: A conceptual framework development. *Journal of Construction Engineering and Management*, 149(1), 03122010.
Yap, J. B. H., Lim, B. L., Skitmore, M., and Gray, J. (2022). Criticality of project knowledge and experience in the delivery of construction projects. *Journal of Engineering, Design and Technology*, 20(3), 800-822.
Zhao, X., Hwang, B. G., and Lim, J. (2020). Job satisfaction of project managers in green construction projects: Constituents, barriers, and improvement strategies. *Journal of Cleaner Production*, 246, 118968.

Yasir Alhammadi is an Assistant Professor at Prince Sattam bin Abdulaziz University. He holds a B.Eng degree in Civil Engineering from King Saud University, an M.Sc. in Construction Management and Engineering from the University of Leeds, and a Ph.D. in Construction Management from Arizona State University. His research directions are value-based contracting and project delivery, performance measurements, facility management, risk management, organizational transformation, and leadership development.

Afiqah R. Radzi received a B.Eng. in Civil and Environmental Engineering from Saitama University. She received her M.Sc. in Project Management and Construction from Universiti Malaysia Pahang Al-Sultan Abdullah. She is currently a Ph.D. student at Universiti Malaya. Her research interests include project management, decision-making, Building Information Modeling (BIM), and digital twin.

Rahimi A. Rahman is an Associate Professor at Universiti Malaysia Pahang Al-Sultan Abdullah in the Faculty of Civil Engineering Technology. He holds B.Eng. and M.Eng. degrees in Civil and Environmental Engineering from Saitama University and a Ph.D. in Civil, Environmental, and Sustainable Engineering from Arizona State University. He is currently a Deputy Director in the Innovation and Commercialization Management Center at Universiti Malaysia Pahang Al-Sultan Abdullah. His research interests include project management, decision management, construction management, and Building Information Modeling (BIM).