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Article

Variations and Claims in International Construction Projects in the MENA Region from Last Decade

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Abstract: This study delves into the dynamics of 'Variations' and 'Claims' in construction projects. The study aims to identify, categorize, and devise mitigation strategies for critical types of variations and claims that are aligned with the contract's FIDIC conditions. The research draws on input from construction industry professionals, including contract administrators and project managers, and focuses on the MENA region. The region's extensive adoption of FIDIC standards and the rapidly growing construction sector drive this choice. Data collection encompassed a questionnaire distributed to 80 industry experts, predominantly through interviews focused on countries like Saudi Arabia, the UAE, Kuwait, and Egypt. Utilizing SPSS-V.25 for statistical analysis, the study uncovers the most prevalent and impactful causes of variations and claims, highlighting the critical need for managerial intervention. A key feature is the integration of scientometric analysis into a quantitative finding. Implementing a k-means clustering analysis is a significant addition to the methodology. The survey had high internal consistency with a Cronbach's alpha of 0.97, and respondents reported frequent and significant claims like delayed drawings, ambiguous documents, and client changes. The results showed that effective claims management requires clear communication and balanced contracts, while poor design and contract documentation cause variations and claims. The correlation analysis showed strong positive correlations between claim types and causes. To reduce claims, address these factors. Most respondents said the survey could predict and reduce claims.

Keywords: construction industry; international contracts; FIDIC 1999 Red Book; variations; claims; scientific metric analysis; statistical analysis; relative importance index (RII); K-means clustering

1. Introduction

The construction industry plays a crucial role in gauging the economic health of a country; its success fosters development and stability, while its failure can negatively impact the economy [1–3]. According to market research conducted until 2020 for the "construction industry" worldwide, the study focuses on global construction forecasts up to the year 2020 and the evolution of the "construction industry" in all major countries. According to the CIC's (Construction Intelligence Center) Global 50s (2010-2020), this encompasses over 50 of the world's biggest and most significant

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markets. This is largely due to the significant investments made in infrastructure and buildings in these regions, despite fluctuations in oil prices and their vulnerability to economic growth [1]. The report also confirmed that the Asia-Pacific region accounts for a growing portion of the global construction industry, rising from 40% in 2010 to nearly 49% in 2020. "Variations" and "claims" are common in the construction industry due to requirements and needs, as well as the growing complexity of construction processes. However, construction industry contracts with huge funding values undergo many "variations" during the project's, design, contracting, and construction stages [1–8]. The primary objectives of this study are to identify and characterize contractual variants and raised claims, in compliance with the employer's FIDIC-Red Book 1999 [9]. Additionally, we aim to identify the significant causes of these variations and claims and provide suggestions for their resolution.

Much research on construction project management has yet to address "variations" and "claims." Abdelalim et al. [1–3,5,6] have improved risk management, quality control, and productivity. Still, there needs to be more focused research on systematically identifying and characterizing significant variations and claims under FIDIC contracts for construction conditions [9]. Existing studies [4,7,8] focus on risk factors rather than contractual issues, making it difficult to determine the causes of these variations and claims. Last, while some studies [9–11] suggest strategic management and risk mitigation, there is a clear need for targeted recommendations and practical solutions that directly address and prevent construction project variations and claims. This gap highlights the need for a more integrated and focused approach to studying variations and claims, aligned with contractual frameworks like FIDIC, to develop construction industry strategies. Based on feedback from construction professionals' experience, clients, consultants, contractors, and experts advocate for the use of survey questionnaires. Other research has tried to find "variations" and "claims" in the terms of the contract for the construction of buildings and engineering works that have already been planned [9]. This study aims to find and describe the main types of "variations" and "claims" in construction projects by looking at the terms of construction contracts [9]. Therefore, the study develops the research objectives:

- identification and characterization of the significant types of "variations" and "claims" in construction projects by the terms of the conditions of construction contracts [9].
- Study the significant causes of the "variations" and "claims" in construction projects.
- Suggest recommendations and proposed solutions to benefit from the study's results and avoid the causes of "variations" and "claims."
- Investigate the causes of claims and variations in the MENA region, which recently has a booming construction market with the involvement of international AEC firms with tremendous budgets.
- Extending the investigation to the last decade will be an advantage, as most current research concentrated on COVID-19 after 2019 and neglected other causes that had been started before the pandemic, which may have more significant effects on the construction industry.

2. Research Methodology

The research methodology adopts a multi-faceted approach, essential for comprehensively addressing the intricacies of Variations and Claims in International Contracts, specifically under FIDIC guidelines. The methodology is structured into distinct but interrelated stages, each contributing uniquely towards achieving our research objectives, as shown in Figure 1.

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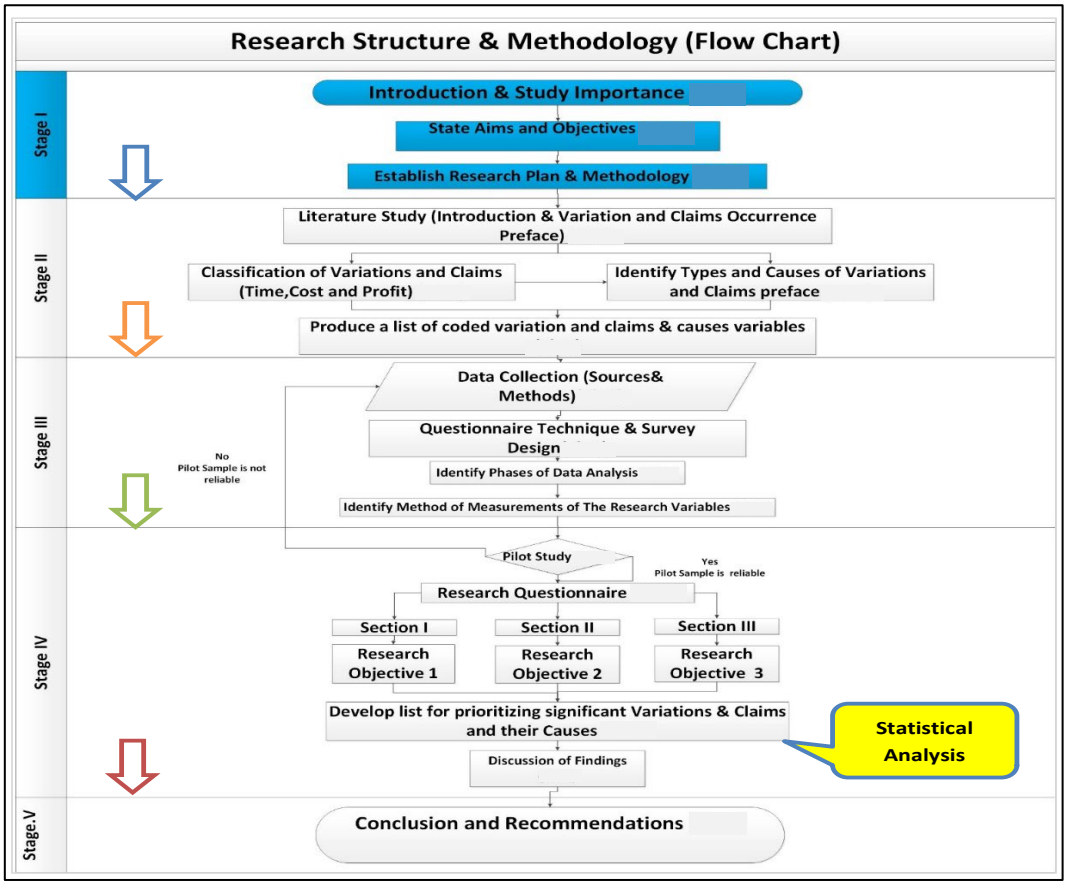

Figure 1. Research Methodology.

Scientometric Analysis

In the scientometric analysis phase of this research, a thorough and systematic examination of the existing scholarly literature on variations and claims in international contracts, with a specific focus on those under the Fédération Internationale Des Ingénieurs-Conseils (FIDIC) framework in the MENA region for such period, is carried out. This examination is pivotal for pinpointing the dominant themes, trends, and notable gaps within this academic field. The research delves into a carefully curated collection of academic journals, conference papers, and industry reports using advanced data analysis tools.

To initiate this analysis, Scopus and Web of Science, a database known for its wide array of scientific publications and rapid indexing, was selected as the primary source for data retrieval. This choice enhances the likelihood of accessing relevant and recent literature in this field. In December 2023, a specific search query was employed to gather data. The query, formulated as "(TITLE-ABS-KEY ("Construction" AND "FIDIC" AND "Claim") OR TITLE-ABS-KEY ("Construction" AND "FIDIC" AND "Variation") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (DOCTYPE) OR LIMIT-TO (DOCTYPE, "ar")," is designed to capture publications that focus on 'Construction,' 'FIDIC,' along with either 'Claim' or 'Variation.'

Recognizing the enduring significance of 'construction claims' as a research topic in the construction sector, the authors decided against setting a time restriction for the publications. Initially, 62 articles are retrieved through this process. Inclusion and exclusion criteria ensure the review's quality and relevance. Either articles not in English and those not categorized as 'journal articles' or 'conference articles' were excluded. This refining process narrows down the selection to 49 manuscripts, which are then downloaded and meticulously reviewed.

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3. Literature Review

Variations and claims generally arise between the employer and the contractor due to their respective rights and obligations under the contract clauses or due to some events or circumstances.

The FIDIC Conditions of Contract tried to ensure the balanced rights of all parties, even when the employers, engineers, and contractors were exposed to claims, the following sections exhibit classification and causes of variations and claims.

3.1. Classification of Variations and Claims

According to the terms and conditions of the contract for the construction of building and engineering works designed by the employer [9], variations and claims between the employer and the contractor are classified into time, cost, and profit claims (Table 1).

Table 1. Classification of Claims according to FIDIC 1999.

No.	FIDIC Sub-Clause	Claim Description	Claim Party		Sort of Claim (Additional)		
			Employer (E)	Contractor (C)	Cost (C)	Profit (P)	Time (T)
1	4.2.a	Failure to extend validity of the performance security	E		C		
2	4.2.b	Failure to pay agreed amount due.	E		C		
3	4.14	Avoidance of Interference	E		C		
4	4.16	Damages, losses and expenses resulting from Transport	E		C		
5	4.19	Payment of electricity, water or gas	E		C		
6	4.2	Employer's equipment or free-issue materials	E		C		
7	7.5	Rejection of defective plant and / or materials	E		C		
8	7.6	Contractor's failure to remedy defects	E		C		
9	8.6	Revised methods of working due to poor rate of progress	E		C		
10	8.7	Delay damages	E		C		
11	9.4	Failed tests on completion	E		C		
12	11.4	A failure to rectify defects	E		C		
13	15.4	Termination by employer	E		C		
14	18.1	Contractor's failure to insure	E		C		
15	18.2	Contractor's inability to insure	E		C		
16	1.9	Delayed drawings or instructions		C	C	P	T
17	2.1	Right of access to, or possession of the site		C	C	P	T
18	4.2	Delay of performance security payment after performance certificate issuing		C	C	P	T
19	4.7	Errors in setting out information		C	C	P	T
20	4.12	Unforeseen physical conditions		C	C		T
21	4.24	Fossils, ancient artefacts, archaeological or geological items		C	C		T
22	7.4	Additional tests instructed by the engineer		C	C	P	T
23	8.4.a	A variation or significant change to the quantities		C			T
24	8.4.c	Unusual bad weather		C			T
25	8.4.d	Shortage of personnel or goods		C			T
26	8.4.e	Employer's delay or impediment		C			T
27	8.5	Delays caused by authorities		C			T
28	8.9	Suspension and/or resuming work after suspension		C	C		T
29	10.2	The Employer using part of the works		C	C	P	
30	10.3	Prevention from undertaking tests on completion		C	C	P	T
31	12.4	An omission of works		C	C		T
32	13.2	An adopted value engineering proposal		C	C	P	
33	13.7	Changes in legislation		C	C		T
34	14.8	Delayed payment		C	C		
35	16.1	Suspension initiated by the contractor		C	C	P	T

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36	16.4	Termination initiated by the contractor	C	C	P	
37	17.1	Damage or injury caused by Employer's personnel agents	C	C		
38	17.4	Ambiguity in Documents	C	C	P	T
39	17.4	Loss or damage to the works caused by Employer's Risks (poor design etc.)	C	C	P	T
40	18.1	Insurances supplied by the Employer's	C	C		
41	19.4	Force Majeure	C	C	P	T
42	19.6	Optional payment and release due to termination	C	C	P	
43	5.2	Refusal of contractor objection to nomination	C	C	P	T
44	11.8	An instruction to search for defect	C	C	P	T
45	8.3	Acceleration of Works	C	C	P	T
46	8.10	Payment for plant and material in event of suspension	C	C		
47	16.2	Client's Breach of Contract	C	C	P	
48	16.2	Inflation / Price Escalation	C	C	P	
49	16.2	Currency Fluctuation	C	C	P	
50	5.2	Default of Nominated Subcontractor or Suppliers	C	C	P	T
51	19.6	Rectification of Damage Due to Unexpected Risk	C	C	P	T

3.2. Causes of Variations and Claims

According to the terms and conditions of the contract for the construction of building and engineering works designed by the employer [9], causes of variations and claims can be classified as shown in Table 2.

Table 2. Causes of Claims [9].

No.	List of Causes	No.	List of Causes
01	Inadequate/ Inaccurate Design Information	16	Inappropriate/ Unexpected Cost Control (Target)
02	Inadequate Design Documentation	17	Inappropriate/ Unexpected Quality Control (Target)
03	Inadequate Brief	18	Poor Communications Among Project Participants
04	Unclear & Inadequate Specifications	19	Lack of Information for Decision Making; (Decisiveness)
05	Inappropriate Contract Type (Strategy)	20	Slow Client Response
06	Inappropriate Contract Form	21	Changes by Client
07	Inadequate Contract Administration	22	Lack of Competence of Project Participants
08	Inadequate Contract Documentation	23	Poor Workmanship
09	Incomplete Tender Information	24	Inadequate Site Investigation
10	Inappropriate Contractor Selection	25	Unrealistic Information Expectations (By Contractor)
11	Unrealistic Tender Pricing	26	Lack of Team Spirit Among Participants
12	Unrealistic Client Expectations	27	Personality Clashes Among Project Participants
13	Inappropriate Payment Method	28	Poor Management By One or More Project Participants
14	Inappropriate Document Control	29	Adversarial Culture Among project Participants
15	Inappropriate/ Unexpected Time Control	30	Uncontrollable External Events
		31	Exaggerated Claims

3.3. Significance and Avoidability

Significance and avoidability are two critical issues addressed in a real strategy for reducing variations and claims. Avoidability concerns the precautions and preventive procedures that can reduce the consequences of variations and claims. Both are essential in studying the causes of claims and recommended responses.

Avoidability as procedures that reduce the negative impacts of claims and variations can be considered as risk mitigation strategy for construction projects.

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4. Results

For deeper analysis, visualization of similarities (VOS), an open-source tool acclaimed for its capability to construct and visualize bibliometric networks, is utilized. This software applies the VOS-viewer technique [10] for this analysis. The process includes examining all keywords in the selected publications, with a predetermined threshold set to include those appearing at least twice. Among 324 keywords, 54 meet this criterion, revealing six main thematic clusters in the analysis, as shown in Figure 2.

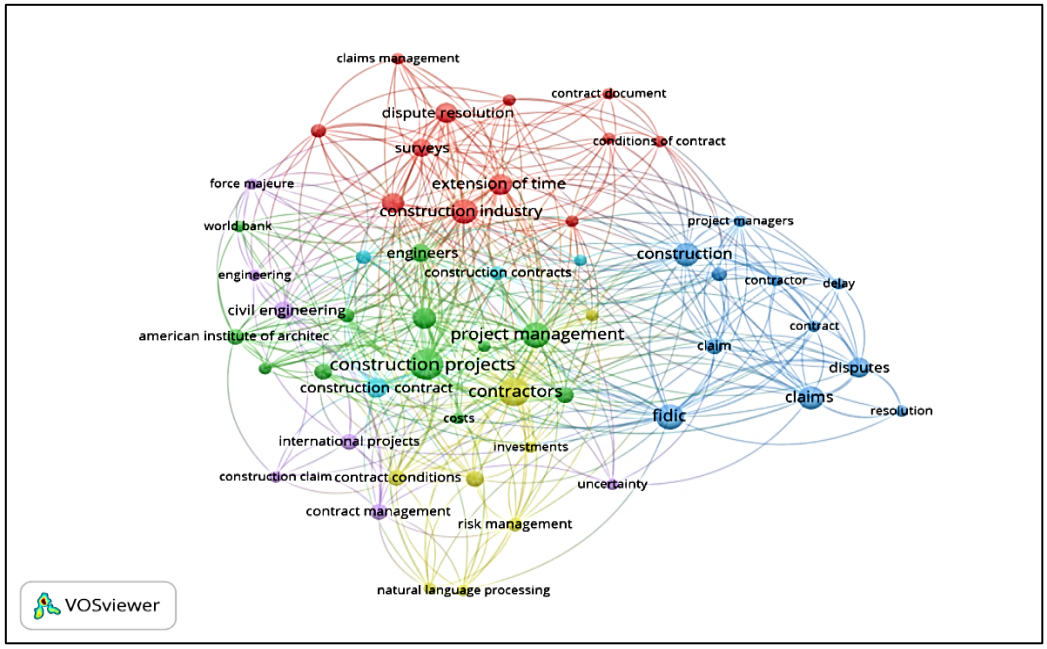

Figure 2. Co-occurrence of the top keywords.

These clusters were visually represented in a keyword co-occurrence network, where each cluster is color-coded, and the size of each node (keyword) indicates its frequency of occurrence. The relationships between keywords were depicted through arcs, with the thickness of each line signifying the strength of the relationship. The clusters identified were the yellow cluster representing 'contractors,' the red cluster for 'construction industry and EOT,' the green cluster signifying 'construction project management,' the purple cluster for 'civil engineering,' the blue cluster denoting 'construction and FIDIC,' and the sky-blue cluster for 'construction contracts.' The most prominent keyword, serving as the central node in this network, is 'construction projects.'

Despite not being constrained by strict keyword thresholds, this visualization highlights a critical observation: previous studies have yet to extensively explore the causes of claims and variations within the context of FIDIC contracts. This gap in the literature underscores the necessity for this research to delve deeply into these aspects, thereby contributing to a more comprehensive understanding of Variations and Claims in construction contracts under FIDIC regulations. There were no similar scholars covering the same period (10 years) in the MENA region in particular.

4.1. Characteristics of the Survey Targeted Participants and Statistical Investigation

The sample size for the survey was determined considering the limited availability of claims & disputes experts. To ensure a statistically representative sample of the population, the following formula was used for the initial calculation:

$$m = \frac{z^2 \times p \times (1-p)}{\varepsilon^2} = \frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.05)^2} = 384 \quad (1)$$

Sample size.

This calculation is based on:

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A confidence level value (z) of 1.96 indicates a 95% confidence level, and an estimated proportion (p) of 0.5 is commonly used when the exact proportion is unknown. A margin of error (ε) set at 0.05 equals 5%.

The initial sample size calculated using this formula was 384. However, a correction was applied to this initial figure due to the finite population of Claims & Disputes experts. The corrected sample size (n) was determined by the following equation, which accounts for the limited population size:

$$n = \frac{m}{1 + \frac{m-1}{N}} = \frac{384}{1 + \frac{384-1}{110}} \approx 80 \quad (2)$$

Correction for Limited Sample Population

In this equation, N represents the total population of Claims & Disputes experts. This adjustment resulted in a final sample size of approximately 80. This methodological approach is critical to ensure that the sample size adequately represents the expert population, enhancing the reliability of the survey results.

As shown in Figures 3 and 4, the characteristics of respondents were classified and denoted into six groups: PC01, PC02, PC03, PC04, PC05, and PC06.

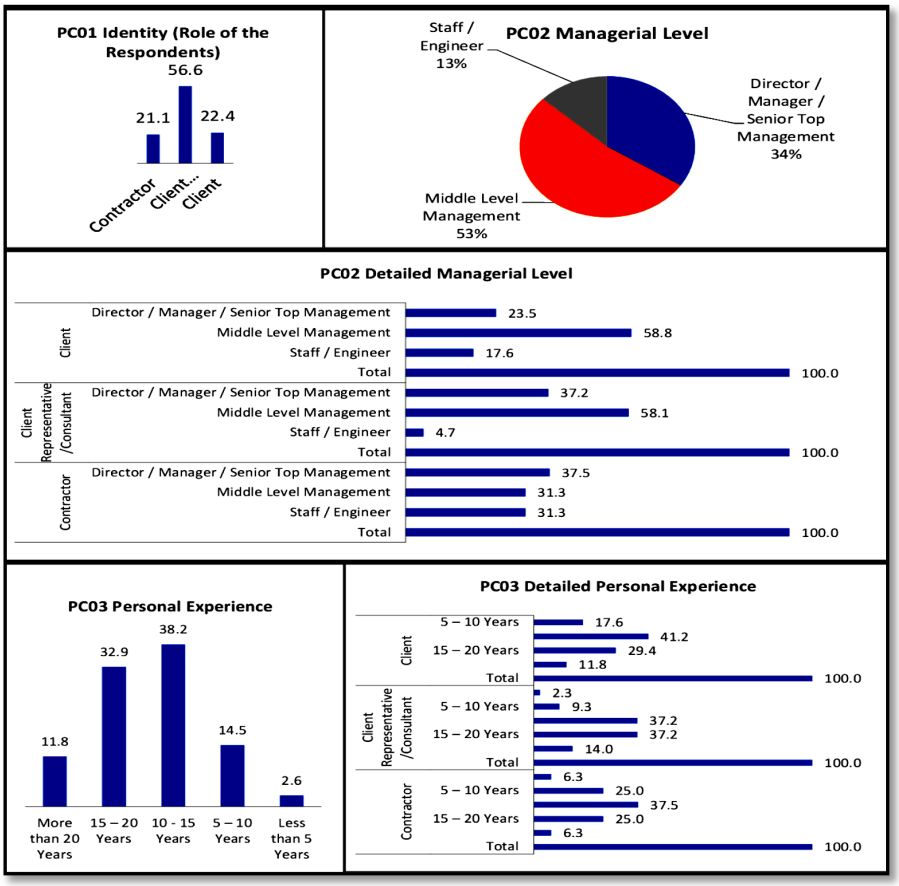

Figure 3. Respondent's Profile (Groups PC01, PC02, PC03).

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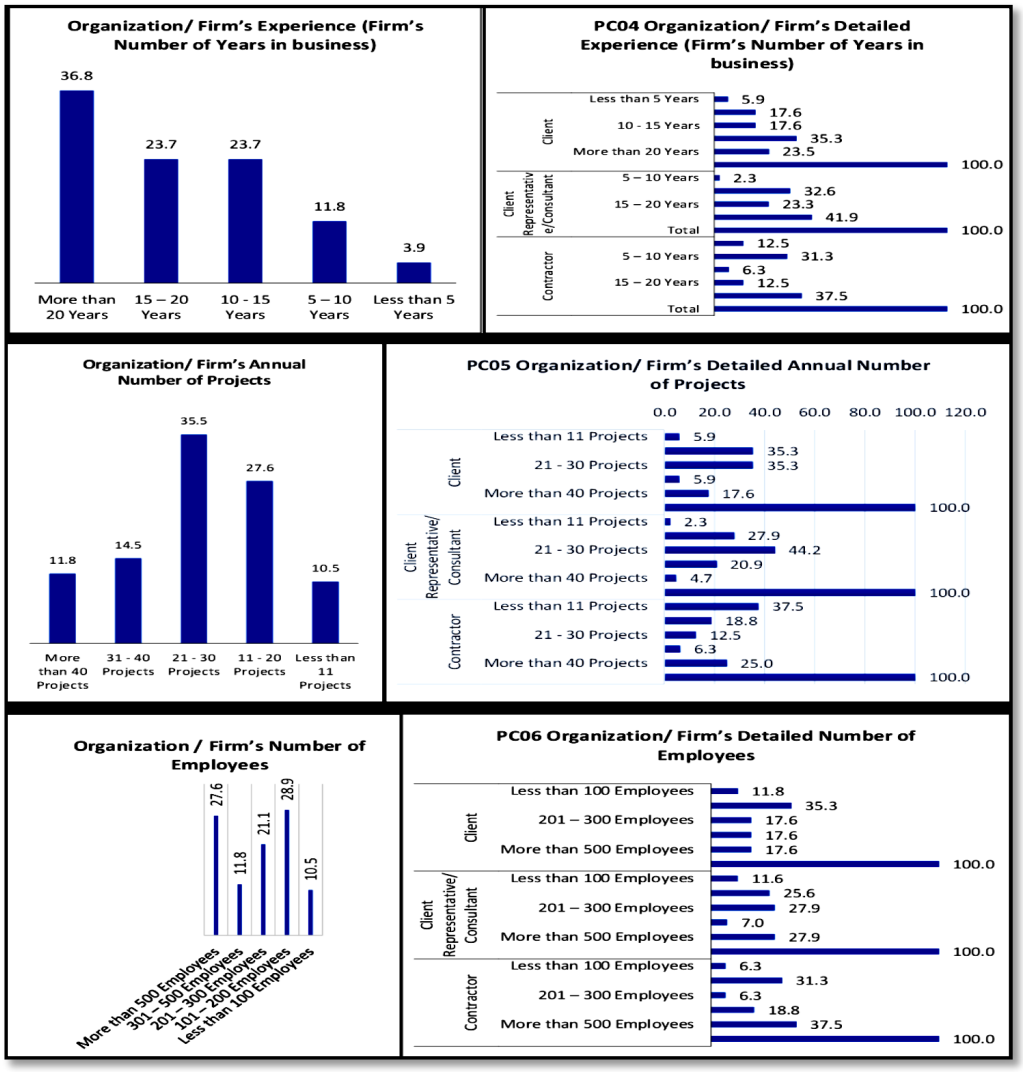

Figure 4. Respondent's Profile (Groups PC04, PC05, PC06).

4.2. Participant Profiles and Group Classifications in the Survey

The survey categorized respondents into six distinct groups, each defined by specific criteria that captured various dimensions of their professional profiles. This categorization facilitated a detailed data analysis, allowing for nuanced insights into industry practices. The groups were as follows:

- PC01—Role of the Respondent (Identity): This classification focused on the professional role of each respondent, identifying their specific position or function within their organization.
- PC02—detailed Managerial Level: Respondents were classified based on their organization's managerial level, offering insights into the decision-making hierarchy and leadership structure.
- PC03—years of Experience: This category evaluated the individual professional experience of respondents, highlighting the depth and range of their expertise in the industry.
- PC04—organization/Firm's Experience (Firm's Number of Years in Business): This group focused on the longevity and historical context of the organizations represented, providing an understanding of the firm's experience and stability in the industry.
- PC05—Organization/Firm's Annual Number of Projects: This classification detailed the scale and scope of operations of the respondents' firms based on the number of projects managed or undertaken annually.
- PC06—Organization/Firm's Number of Employees: This group provided insights into the organizations' size and human resource capacity, highlighting the scale of their operations regarding personnel.

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Figures 3 and 4 follow to provide visual representations of these classifications, illustrating the diversity and distribution of the participant pool across these varied criteria.

4.3. Evaluation of Survey Validity and Reliability

The survey underwent a rigorous evaluation for validity and reliability, focusing on types of variations and claims regarding frequency, impact, and underlying causes. The validity was quantitatively established with a Cronbach's alpha value of 0.97, indicating a high level of internal consistency since this value notably surpasses the commonly accepted threshold of 0.70. Furthermore, the lowest item-total statistic in the survey did not fall below 0.969, reinforcing the validity of the findings. Regarding reliability, the corrected item-total correlation for all dependent and independent survey factors exceeded 0.30.

4.4. Relative Importance Index Test (RII)

The survey incorporated the relative importance index (RII) to analyze participants' perceptions of various factors. Respondents were requested to assign a rating to each factor, ranging from 1 ('very rare') to 5 ('very high'). Absent responses were not assigned any weight in the RII calculation. This rating system facilitated categorizing responses into five levels of importance: extremely rare (deficient), rare (low), average, high, and very high.

4.5. Assessment of Frequency for Types of Variations and Claims

Respondents from clients, consultants, and contractors were collectively evaluated in assessing the frequency of different variations and claims, as summarized in Table 3. This analysis identified fifty-one distinct types of variations and claims, initially detailed in Table 1. Ten types emerged as the most frequently encountered in projects, consistently reported across all respondent groups. The remaining forty-one types were notably less frequent, indicating a lower occurrence rate in construction projects.

Table 3. Classification of claims.

Code#	Type	Type Frequency					Type Frequency Index		
		Very Low	Low	Average	High	Very High	Mean	RII	Rank
T16	Delayed drawings or instructions	1	5	48	16	6	3.28	65.53	1
T23	A variation or significant change to the quantities	3	4	44	19	6	3.28	65.53	2
T38	Ambiguity in Documents	5	13	43	11	4	2.95	58.95	3
T45	Acceleration of Works	3	10	54	9	0	2.91	58.16	4
T31	An omission of work forming	3	18	48	7	0	2.78	55.53	5
T34	Delayed payment	2	25	43	4	2	2.72	54.47	6
T25	Shortage of personnel or goods	2	38	29	4	3	2.58	51.58	7
T07	Rejection of defective plant and / or materials	3	36	30	7	0	2.54	50.79	8
T09	Revised methods of working due to slow progress	3	38	28	6	1	2.53	50.53	9
T10	Delay damages	3	36	33	2	2	2.53	50.53	10

4.6. Assessment of Impact for Types of Variations and Claims

The impact assessment of variations and claims is based on the collective feedback from clients, consultants, and contractors (Table 4). This evaluation aimed to understand the severity of different types of variations and claims as experienced in the industry.

The analysis revealed that 32 variations and claims were frequently identified as significantly impacting construction projects. In contrast, 19 types were perceived to have a less severe impact, suggesting that their occurrence typically results in less disruption or fewer consequences for the projects involved.

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Table 4. Causes of Claims according to Respondents.

Code#	Type	Type Impact					Type Impact Index		
		Very Low	Low	Average	High	Very High	Mean	RII	Rank
T39	Loss or damage to the works caused Employer's Risks (War, riots, munitions, poor design.	6	2	4	18	46	4.26	85.26	1
T47	Client's Breach of Contract	4	5	2	21	44	4.26	85.26	2
T16	Delayed drawings or instructions	1	3	7	34	31	4.20	83.95	3
T41	Force Majeure	3	7	7	24	35	4.07	81.32	4
T27	Delays caused by authorities	2	4	3	46	21	4.05	81.05	5
T38	Ambiguity in Documents	1	4	7	42	22	4.05	81.05	6
T33	Changes in legislation	7	3	2	40	24	3.93	78.68	7
T23	A variation or change of the quantities	2	1	16	42	15	3.88	77.63	8
T26	Employer's delay or impediment	4	1	23	41	7	3.61	72.11	9
T48	Inflation / Price Escalation	3	2	27	34	10	3.61	72.11	10

4.7. Causes of Variations and Claims (Perceived Agreement Assessment)

Every replying group affirmed the possibility that the majority of the causes listed above could result in claims and variances in construction projects. With varying degrees of agreement, each group concurred that 31 possible causes could lead to these construction variations and claims.

This illustrates the disparities in agreement as each group perceived it. The assessment of the cause by the different responding groups (i.e., clients, consultants, and contractors) was compared using Table 5. The generation of different construction variations and claims can be attributed to these thirty-one proposed causes. However, this bias is not unexpected; others have already noted [11].

Table 5. Causes of Claims Assessment.

Code	Cause Description	Clients	Consultants	Contractors	Overall
C01	Inadequate/ Inaccurate Design Information	100.00%	100.00%	93.80%	98.68%
C21	Changes by Client	100.00%	97.70%	87.50%	96.05%
C19	Lack of Information for Decision Making; (Decisiveness)	100.00%	93.00%	93.80%	94.74%
C23	Poor Workmanship	100.00%	90.70%	100.00%	94.74%
C30	Uncontrollable External Events	100.00%	93.00%	93.80%	94.74%
C02	Inadequate Design Documentation	94.10%	95.30%	87.50%	93.42%
C04	Unclear & Inadequate Specifications	94.10%	97.70%	81.30%	93.42%
C16	Inappropriate/ Unexpected Cost Control (Target)	100.00%	93.00%	87.50%	93.42%
C09	Incomplete Tender Information	88.20%	95.30%	87.50%	92.11%
C15	Inappropriate/ Unexpected Time Control (Target)	100.00%	93.00%	81.30%	92.11%
C22	Lack of Competence of Project Participants	94.10%	93.00%	81.30%	92.11%
C05	Inappropriate Contract Type (Strategy)	88.20%	95.30%	81.30%	90.79%
C08	Inadequate Contract Documentation	94.10%	93.00%	81.30%	90.79%
C18	Poor Communications Among Project Participants	100.00%	90.70%	81.30%	90.79%
C20	Slow Client Response	100.00%	90.70%	81.30%	90.79%
C31	Exaggerated Claims	100.00%	93.00%	75.00%	90.79%
C07	Inadequate Contract Administration	88.20%	95.30%	75.00%	89.47%
C11	Unrealistic Tender Pricing	100.00%	86.00%	87.50%	89.47%
C14	Inappropriate Document Control	100.00%	86.00%	87.50%	89.47%
C24	Inadequate Site Investigation	94.10%	88.40%	87.50%	89.47%
C03	Inadequate Brief	94.10%	88.40%	81.30%	88.16%
C12	Unrealistic Client Expectations	100.00%	86.00%	81.30%	88.16%
C17	Inappropriate/ Unexpected Quality Control (Target)	100.00%	81.40%	93.80%	88.16%
C26	Lack of Team Spirit Among Participants	94.1%	90.70%	75.00%	88.16%
C28	Poor Management By One or More Project Participants	94.1%	86.00%	87.50%	88.16%
C10	Inappropriate Contractor Selection	94.1%	88.40%	75.00%	86.84%
C06	Inappropriate Contract Form	88.20%	88.40%	75.00%	85.53%
C25	Unrealistic Information Expectations (By the Contractor)	94.10%	86.00%	75.00%	85.53%

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C27	Personality Clashes Among Project Participants	94.10%	86.00%	75.00%	85.53%
C29	Adversarial (industry) Culture Among project Participants	94.10%	86.00%	75.00%	85.53%
C13	Inappropriate Payment Method	94.10%	86.00%	68.80%	84.21%

4.8. Causes of Variations and Claims (Perceived Significance Assessment)

The responses for the cause's significant assessment from the viewpoint of all respondents for the first ten categories of variations and claims are shown in Table 6.

Table 6. Assessment of claims significance (Top 10).

Code #	Cause Description	Cause Significance					Cause Significance Index		
		Very Low	Low	Average	High	Very High	Mean	RII	Rank
C15	Inappropriate/ Unexpected Time Control (Target)	3	3	7	16	47	4.33	**86.58**	1
C10	Inappropriate Contractor Selection	1	3	8	23	41	4.32	**86.32**	2
C05	Inappropriate Contract Type	4	3	8	12	49	4.30	**86.05**	3
C16	Inappropriate/ Unexpected Cost Control (Target)	3	4	7	15	47	4.30	**86.05**	3
C21	Changes by Client	3	3	6	20	44	4.30	**86.05**	3
C19	Lack of (Decisiveness)	2	6	5	18	45	4.29	**85.79**	4
C20	Slow Client Response	2	5	5	28	36	4.20	**83.95**	5
C17	Inappropriate/ Unexpected QC	5	2	10	22	37	4.11	**82.11**	6
C01	Inadequate/ Inaccurate Design	2	3	7	38	26	4.09	**81.84**	7
C06	Inappropriate Contract Form	5	4	6	25	36	4.09	**81.84**	7

4.9. Causes of Variations and Claims (Perceived Avoidability Assessment)

Analysis was done on the responses from the different groups about the avoidability of factors that can lead to or "trigger" the kinds of variations and claims.

Nonetheless, the analysis of the total response data is presented in Table 7. The answers for the top 10 avoidable causes of variations and claims are shown in Table 7.

Table 7. The Top Ten Avoidable Causes of Variations and Claims.

Code #	Cause Description	Cause Avoid-ability					Cause Avoid-ability Index		
		Very Low	Low	Average	High	Very High	Mean	RII	Rank
C10	Inappropriate Contractor Selection	2	5	23	41	5	3.55	**71.05**	1
C13	Inappropriate Payment Method	4	3	20	47	2	3.53	**70.53**	2
C06	Inappropriate Contract Form	3	7	25	31	10	3.50	**70.00**	3
C05	Inappropriate Contract Type (Strategy)	3	6	31	24	12	3.47	**69.47**	4
C01	Inadequate/ Inaccurate Design Information	2	5	34	31	4	3.39	**67.89**	5
C24	Inadequate Site Investigation	1	5	39	26	5	3.38	**67.63**	6
C04	Unclear & Inadequate Specifications	1	7	40	25	3	3.29	**65.79**	7
C02	Inadequate Design Documentation	1	8	44	19	4	3.22	**64.47**	8
C08	Inadequate Contract Documentation	1	10	42	21	2	3.17	**63.42**	9
C07	Inadequate Contract Administration	4	4	51	15	2	3.09	**61.84**	10
C09	Incomplete Tender Information	1	8	53	11	3	3.09	**61.84**	10

5. Discussion

In this study, various statistical analysis methods were pivotal for comprehensively understanding the intricate dynamics of Variations and Claims in FIDIC contracts in the MENA region. Each method contributed uniquely to unraveling different facets of the data, starting with descriptive and inferential statistics. This allowed for establishing a foundational understanding of the data distribution and relationships among variables.

Advancing to more complex analyses like the relative importance index (RII) and Spearman's correlation obtained more profound insights into the significance and interconnectedness of factors influencing variations and claims.

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5.1. Analysis of the Findings (Statistical Hypothesis- Kruskal Wallis Test)

According to the null hypothesis, each population median is equal. A significance threshold 0.05 (represented as α or alpha) is typically adequate. A 5% chance of determining that a difference exists when there is not one is indicated by a significance level of 0.05. P-value < α indicates statistical significance in the discrepancies between some medians. The null hypothesis is true if the p-value is less than or equal to the significance level.

Most of the 6 group respondents to this statistical test said that except T12, which is statistically significant about personal experience (PC03) with a p-value of less than 0.05. The differences between the medians are not statistically significant. As a result, not all group medians are equal, and the null hypothesis was rejected. Furthermore, T14's relationship to the organization/firm's experience (PC04) was statistically significant with a p-value of 0.01. The null hypothesis was rejected, indicating that not all item medians are identical, and T16 was also statistically significant about organization/firm's experience (PC04), with a p-value of =0.009 (lower than 0.05). T39 showed statistical significance about the organization's or firm's annual number of projects (PC05) with p-value =0.007. Regarding frequency, it is evident that most variations and claims have no statistically significant disparities between the medians; refer to Appendix B.

5.2. Kruskal Wallis Test (Types of Variations and Claims – Impact)

For this statistical test, most of the group respondents (PC01, PC02, PC03, PC04, PC05, PC06) responded that the differences between the medians are not statistically significant except for the PC01 group we find that T11, T49, T02, T21, T45, T27, T38 and T43 with p-value of 0.002,0.005,0.007,0.035,0.040,0.041,0.042 and 0.049 respectively. In addition, for the Managerial level PC02 group, it was found that T32, T29, T22, and T25 are statistically significant with p-value = 0.026, 0.028, 0.038, and 0.046, respectively. In addition, for the PC03 group, note that only one type, T49, is statistically significant with p-value =0.0.044. For the PC04 group, the T02 and T11 types are statistically significant, with p-values =0.012 and 0.021, respectively. For the PC05 group, the T16 and T39 types are statistically significant, with p-values =0.009 and 0.013, respectively. Finally, the PC06 group has three types, T16, T47, and T26 are statistically significant with p-value =0.032, 0.040, and 0.040.

Most variations and claims in terms of impact have no differences between the group respondents' medians, which are not statistically significant, as shown in Appendix C.

5.3. Kruskal Wallis Test (Cause of Variations and Claims – Agreement)

For this statistical test, most of the group respondents (PC01, PC02, PC03, PC04, PC05, and PC06) responded that the differences between the medians are not statistically significant except for the PC01 group; it was found that one cause, C31 with a p-value of 0.029. In addition, in the PC02 group, no causes are statistically significant. However, for the PC03 group, note that only one type, C12, C11, C19, C20, C30, C14, and C10, are statistically significant with p-values equals 0.006, 0.009, 0.021, 0.024, 0.026, 0.026, and 0.027 respectively. For PC04 group C04, C06, C08, C10, C14, C07, C12, C29, C11, C17, C20, C25, C13, C28, C24, C03, C27 and C2 are statistically significant with p-value =0.00, 0.00, 0.001, 0.003, 0.005, 0.005, 0.005, 0.010, 0.011, 0.019, 0.021, 0.027, 0.027, 0.039, 0.041, 0.044, 0.048, 0.050 respectively. Too, PC05 group C06, C05, C12, C03, C11, C25, C09, and C29 are statistically significant with p-values =0.002, 0.003, 0.004, 0.011, 0.015, 0.023, 0.025 and 0.042 respectively. Finally, PC06 group C27, C24, C29, C25, C17, C14, C13, C03, C06, C16, C02, C20, C28, C18, C11, C09, C30, C19 are statistically significant with p-value lower than 0.05.

Most of the causes of variations and claims in terms of agreement have no differences between the group respondents' medians that were not statistically significant, as shown in Appendix D.

5.4. Kruskal Wallis Test (Cause of Variations and Claims – Significance)

Similarly, most of the group respondents (PC01, PC02, PC03, PC04, PC05, PC06) responded that the differences between the medians are not statistically significant except for PC01 group we found

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that causes C29, C20, C12, C03, C01, C07, C23, C15, C28, C05, C11, C18 and C09 with p-value of 0.001, 0.004, 0.009, 0.011, 0.012, 0.012, 0.019, 0.025, 0.031, 0.0310, 035, 0.037 and 0.046 respectively. In addition, the PC02 group has no statistically significant causes. Although the PC03 group has three types, C04, C10, and C20 are statistically significant with p-values =0.025, 0.039, and 0.043, respectively. Also, The PC04 group has three causes: C04, C11, and C18, which are statistically significant with p-values =0.014, 0.020, and 0.039, respectively. Too, PC05 group C20, C15, C21, C10, C05, C01, C29, C16, and C29 are statistically significant with p-values =0.003, 0.006, 0.009, 0.009, 0.012, 0.013, 0.027, 0.027 and 0.048 respectively. Finally, for PC06 group; C17, C15, C05, C07, C10, C19, C21, C16, C08, C24, C13, C06 and C29 are statistically significant with p-value lower than 0.05.

Most of the causes of variations and claims in terms of significance have no differences between the group respondents' medians that are not statistically significant (see Appendix E).

5.5. Kruskal Wallis Test (Cause of Variations and Claims – Avoid-Ability)

Similarly, most of the group respondents (PC01, PC02, PC03, PC04, PC05, and PC06) responded that the differences between the medians are not statistically significant except for the PC01 group; it was found that three causes, C06, C08, and C21 with a p-value of 0.011, 0.017 and 0.034 respectively. In addition, the PC02 group has no causes statistically significant. However, the PC03 group has three types, C09, C30, and C10 are statistically significant with p-values =0.010, 0.036, and 0.044, respectively. The PC04 group has three causes; C06, C13, and C02 are statistically significant with p-values =0.020, 0.029, and 0.032, respectively. However, the PC05 group has no statistically significant causes. Finally, the PC06 group has one statistically significant cause, C13, with a p-value lower than 0.05, which = 0.008.

Most causes of variations and claims regarding avoid-ability have no differences between the group respondents' medians that were not statistically significant (see Appendix F).

5.6. Spearman's Correlation Test

It is known that the relationship appears in 3 phases; the first phase was ($- r < 0$), meaning a negative relationship exists between the two variables. The second phase is that ($+ r > 0$), which means a positive relationship between the two variables. The third phase is ($r = 0$), meaning there is no relationship between the two variables.

To understand the Spearman correlation coefficient, if the correlation coefficient value (r) = 0, there is no relationship between variables. While the correlation coefficient value ($0.0 < r < 0.25$) indicated a weak positive relationship. The correlation coefficient value ($0.25 \leq r < 0.75$) indicated an average positive relationship. However, there was a strong positive relationship if the correlation coefficient value ($0.75 \leq r < 1$). The relationship is entirely positive if the correlation coefficient value equals 1 ($r = 1$).

Regarding the correlation hypothesis, if $r = 0$, there is no relation between the two variables and accepting the zero hypothesis (H0), but if r is not equal to 0, there is a relation between the two variables and rejecting the zero hypothesis (H0) and accept the alternative hypothesis (H1). While if sig. > 0.05, accept the zero hypothesis (H0), but if sig. < 0.05 the zero hypothesis (H0) will be refused.

5.6.1. Spearman's Correlation Test (Types-Frequency) & (Causes-Significance)

It appears that there was a highly positive correlation, denoted by red color, related to the p-value (see Appendix G). Moreover, those denoted by green revealed the correlation between significant causes: C21, C10, C05, and frequent types T16, T23, T38, and T31. While it was lower than 0.05, the H0 hypothesis was not accepted, and the H1 hypothesis was accepted alternatively. Similarly, for significant causes, C15, C16, and C17 correlated with frequented types T16, T23, and T31. Also, a significant cause of C19 is the correlation between frequent types T16, T23, T45, and T31. In addition, the significant cause of C20 correlated with frequent types T16, T23, T38, and T31.

The same is true for significant cause C01, which correlated with frequent types T16, T38, T31, T07, and T09.Finally, significant cause C06 had a correlation relationship with frequent types T16,

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T23, T38, T31, T34 and T10. For the correlation hypothesis, while the significance is lower than 0.05, reject the H0 zero hypotheses and accept the H1 alternative hypothesis in Appendix G.

5.6.2. Spearman Correlation Test (Types-Impact) & (Causes -Significance)

There appears to be a highly positive correlation for the mentioned correlation coefficient by red color, related to the p-value. The green color reveals that there was a correlation relationship between significant causes C21, C16, C17, C20, and C01 and Impacted types T39, T47, T16, T41, T27, T38, T33, T23, T26, while it is lower than 0.05. Therefore, the H0 was rejected, and the H1 hypothesis was accepted alternatively. Similarly, for significant cause C10 that had a correlation relationship with Impacted types T39, T47, T16, T41, T27, T38, T33 and T26.

In addition, significant causes C05, C15 have a correlation relationship with impacted types T39, T47, T16, T41, T27, T38, T33, T23, T26 and T48. In addition, the significant cause C19 had a correlation relationship with Impacted types T39, T47, T16, T41, T27, T38, T33, T26, and T48.Finally for significant cause C06 has a correlation relationship with Impacted types T39, T47, T16, T41, T27, T38, T33 and T26. For the correlation hypothesis, while the significance was lower than 0.05, we will not accept the H0 zero hypothesis and accept the H1 alternative hypothesis in Appendix H

5.6.3. Spearman Correlation Test (Types-Frequency) & (Causes –Avoid-Ability)

Similarly, there was a highly positive correlation for the mentioned correlation coefficients by red color, related to p-value (significant), which had green color revealing a correlation relationship between avoidable cause C10 and frequent types T23, T38. Also, for avoidable causes, C13 correlated with frequented types T38, T45, and T31. Also, avoidable cause C06 correlated with frequented types T16, T23, T38, and T31. In addition, the avoidable cause C05 correlated with frequented types T16, T31, and T09. Moreover, for avoidable causes, C01, C04, and C09 correlate with frequented type T09. On the other hand, the avoidable cause C05 correlated with frequent types T38 and T09. However, the avoidable cause C02 correlated with frequented types T38, T07, T09, and T10. Meanwhile, the avoidable cause C07 did not correlate with any frequent types.

Finally, the avoidable cause C08 correlated with frequent T38, T09, T45, and T10 types. For the correlation hypothesis, the significance was lower than 0.05 to exclude the H0 zero hypotheses and accept the H1 alternative hypothesis in Appendix I.

5.6.4. Spearman Correlation Test (Types-Impact) & (Causes –Avoid-Ability)

The correlation between the most impacted types and the most avoidable causes was investigated using Spearman's test (see Appendix J). It appears that there was a highly positive correlation denoted by red color, related to p-value, which has green color reveals that there is a correlation relationship between avoidable cause C10 and impacted types T47, T16, T41, T27 while significant was lower than 0.05, so we will not accept the H0 and accept the H1 alternative hypothesis. For avoidable causes, C13 correlated with impacted types T47, T41, T27, and T38. In addition, avoidable cause C06 had a correlation with impacted types T39, T47, T18, T41, T27, T38, T33 and T26. In addition, avoidable cause C05 had a correlation with impact types T39, T47, T16, T27, T38, T33 and T26.

Moreover, for avoidable causes, C01 and C01 correlated with impacted types T47 and T33.On the other hand, the avoidable cause C24 correlated with impacted types T47, T27, T38, T33, T23, T26, and T48. However, the avoidable cause C02 correlated with impacted types T41, T27, T38, T33 and T26.In contrast, the avoidable causes C04 and C09 do not correlate with any impacted types. Moreover, the avoidable cause C08 had a correlation with impacted types T47, T16, T27, T38, T33, T26 and T48. Finally, the avoidable cause C07 correlated with impacted type T33.

5.7. Overall, the Questionnaire Participant's Assessment

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Respondents were asked to score the questionnaire's overall coverage in this area and the variables under each section. Additionally, they provided any other remarks on the parts of the variable and any related issues.

Table 8 presents respondents' responses regarding the types of variations and claims and their significance, where 94.1 % of the clients think that the common types of variations and claims are significant, for the consultants, 88.4 % think that it was significant, and 93.8% for the contractors.

Table 8. Respondents' responses regarding the types of variations and claims and its significance.

Identity (Role of the Respondents)		Frequency	Percent	Valid %	Cumulative %
Client	Not Sure	1	5.9	5.9	5.9
	Yes	16	94.1	94.1	100.0
	Total	17	100.0	100.0	
Client Representative/Consultant	No	3	7.0	7.0	7.0
	Not Sure	2	4.7	4.7	11.6
	Yes	38	88.4	88.4	100.0
	Total	43	100.0	100.0	
Contractor	No	1	6.3	6.3	6.3
	Yes	15	93.8	93.8	100.0
	Total	**16**	**100.0**	**100.0**	

Table 9 presents respondents' responses regarding the causes of variations and claims and their significance, where 88.2 % of the clients think that the common types of variations and claims are significant, for the consultants, 95.3 % think that it was significant; finally, for the contractors, 93.8 think that it was significant.

Table 9. Respondents' responses regarding the causes of variations and claims and its significance.

Identity (Role of the Respondents)		Frequency	Percent	Valid %	Cumulative %
Client	No	1	5.9	5.9	5.9
	Not Sure	1	5.9	5.9	11.8
	Yes	15	88.2	88.2	100.0
	Total	17	100.0	100.0	
Client Representative/Consultant	No	1	2.3	2.3	2.3
	Not Sure	1	2.3	2.3	4.7
	Yes	41	95.3	95.3	100.0
	Total	43	100.0	100.0	
Contractor	No	1	6.3	6.3	6.3
	Yes	15	93.8	93.8	100.0
	Total	16	100.0	100.0	

Table 10 presents respondents' responses and questions to help managers predict the significance of types and causes of variations and claims. 94.1 % of the clients think that the survey questions will help managers predict the significance of types and causes of variations and claims; 83.7% of the consultants think that it will help, and 93.8% of the contractors think it will help positively.

Table 10. Will questions help managers predict the types and causes of variations and claims?

Identity (Role of the Respondents)		Frequency	Valid %	Cumulative %
Client	No	1	5.9	5.9
	Yes	16	94.1	100.0
	Total	17	100.0	
Client Representative/Consultant	No	1	2.3	2.3

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	Not Sure	6	14.0	16.3
	Yes	36	83.7	100.0
	Total	43	100.0	
	Not Sure	1	6.3	6.3
Contractor	Yes	15	93.8	100.0
	Total	16	100.0	

The questionnaire responses, shown in Table 11 below, will assist managers in forecasting and suggesting tactics to prevent or lessen variations and claims. Meanwhile, 76.5% of clients believe managers can anticipate and provide ways to prevent or lessen variations and claims. 79% of consultants believe it would be helpful, and eighty-seven percent of contractors believe it will be beneficial.

Table 11. Can questions help managers predict strategies for reducing variations and claims?

Identity (Role of the Respondents)		**Frequency**	**Valid %**	**Cumulative %**
	No	2	11.8	11.8
Client	**Not Sure**	**2**	**11.8**	**23.5**
	Yes	13	76.5	100.0
	Total	**17**	**100.0**	
	No	1	2.3	2.3
Client Representative/Consultant	**Not Sure**	**8**	**18.6**	**20.9**
	Yes	34	79.1	100.0
	Total	**43**	**100.0**	
	Not Sure	2	12.5	12.5
Contractor	**Yes**	**14**	**87.5**	**100.0**
	Total	**16**	**100.0**	

5.8. K-Means Analysis

This section delves into the K-means clustering algorithm, a pivotal tool in data analytics renowned for its simplicity and efficiency. This method is particularly valuable for the study as it complements the previously discussed Spearman's Correlation and Kruskal Wallis tests, offering a unique perspective on understanding the dynamics of factors influencing variations and claims in construction contracts. K-means clustering is a widely embraced and substantiated technique in clustering [12].

To determine the appropriate number of clusters (k), various methodologies such as the Hubert statistic, Davies Bouldin index, Dunn index, score function, elbow plot, and silhouette plot have been devised [13]. In this study, the elbow plot method, known for its reliability [14], [15–23], was employed for cluster count determination.

The primary aim of the k-means algorithm is to minimize cluster inertia or the within-cluster sum-of-squares criterion, as delineated by Equation 3, wherein X_i represents samples and U_j stands for the mean of samples within each cluster. The determination of the suitable number of clusters is validated through the elbow plot, displaying distortion scores for a selected number of clusters as per Equation 3. The "elbow" point designates the cluster count at which further additions do not significantly reduce WCSS. Notably, in this analysis, the optimal number of clusters was identified as four, evident in Figure 5.

$$\boldsymbol{WCSS} = \sum_{\boldsymbol{i=0}}^{\boldsymbol{n}} \boldsymbol{min}_{\boldsymbol{U_j \in C}} \left(\|\boldsymbol{X_i} - \boldsymbol{U_j}\|^{\boldsymbol{2}} \right) \quad (3)$$

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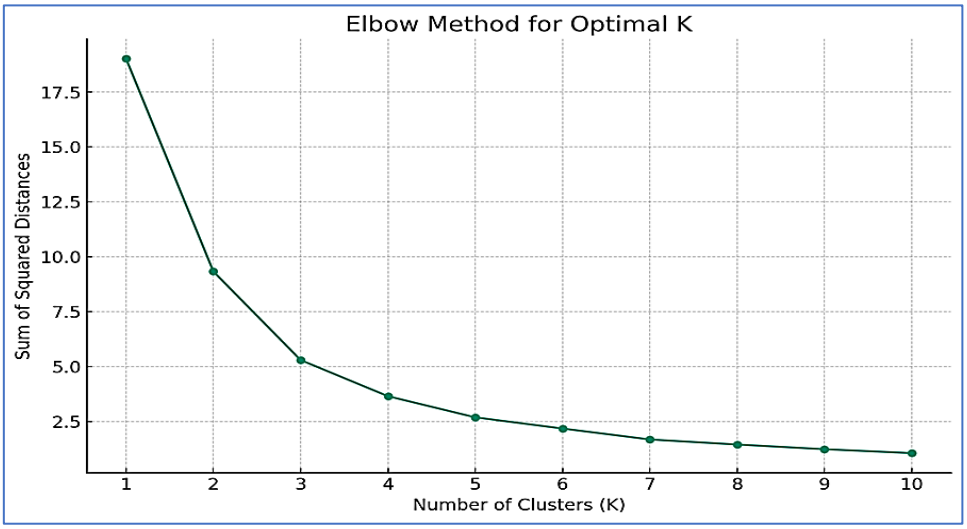

Figure 5. Elbow plot for the distortion score for the number of clusters.

Cluster 0—selective high-impact causes: This cluster includes causes T45, T40, T35, T25, and T24. It is characterized by a significant impact with fewer occurrences and demands focused attention due to its potential substantial effect on projects.

Cluster 1—diverse low-impact causes: With 17 causes (T1, T49, T44, T42, T41, T27, T50, T20, T18, T26, T51, T6, T5, T4, T3, T15, T14), this cluster represents varied and numerous issues of lower individual impact but requiring broad management strategies due to their collective presence.

Cluster 2 - frequent mid-impact causes: The largest cluster with 26 causes (T47, T48, T34, T2, T7, T39, T38, T37, T8, T46, T43, T33, T31, T17, T19, T13, T21, T22, T32, T12, T10, T9, T28, T29, T30, T11), posing a consistent challenge and requiring regular monitoring.

Cluster 3—critical high impact and high-frequency cause: Comprising T23, T36, and T16, these issues are high in impact and frequency, pivotal in the project lifecycle, and necessitating strategic management. Figure 7 visually supports this analysis by showing the network model colored by cluster and detailing the causes of claims within each cluster. Table 12 illustrates these findings, providing a granular view of each cluster's characteristics.

Table 12. Causes of claims and variations assigned to K-means clusters.

Cluster	Cause	Count
0	T45, T40, T35, T25, T24	5
1	**T1, T49, T44, T42, T41, T27, T50, T20, T18, T26, T51, T6, T5, T4, T3, T15, T14**	**17**
2	T47, T48, T34, T2, T7, T39, T38, T37, T8, T46, T43, T33, T31, T17, T19, T13, T21, T22, T32, T12, T10, T9, T28, T29, T30, T11	26
3	**T23, T36, T16**	**3**

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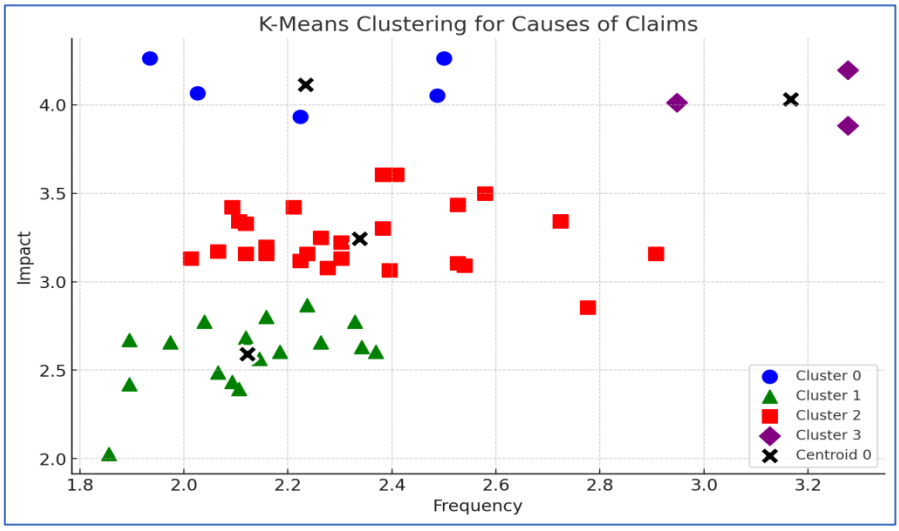

Figure 6. K-Means Clustering for Causes of Claims.

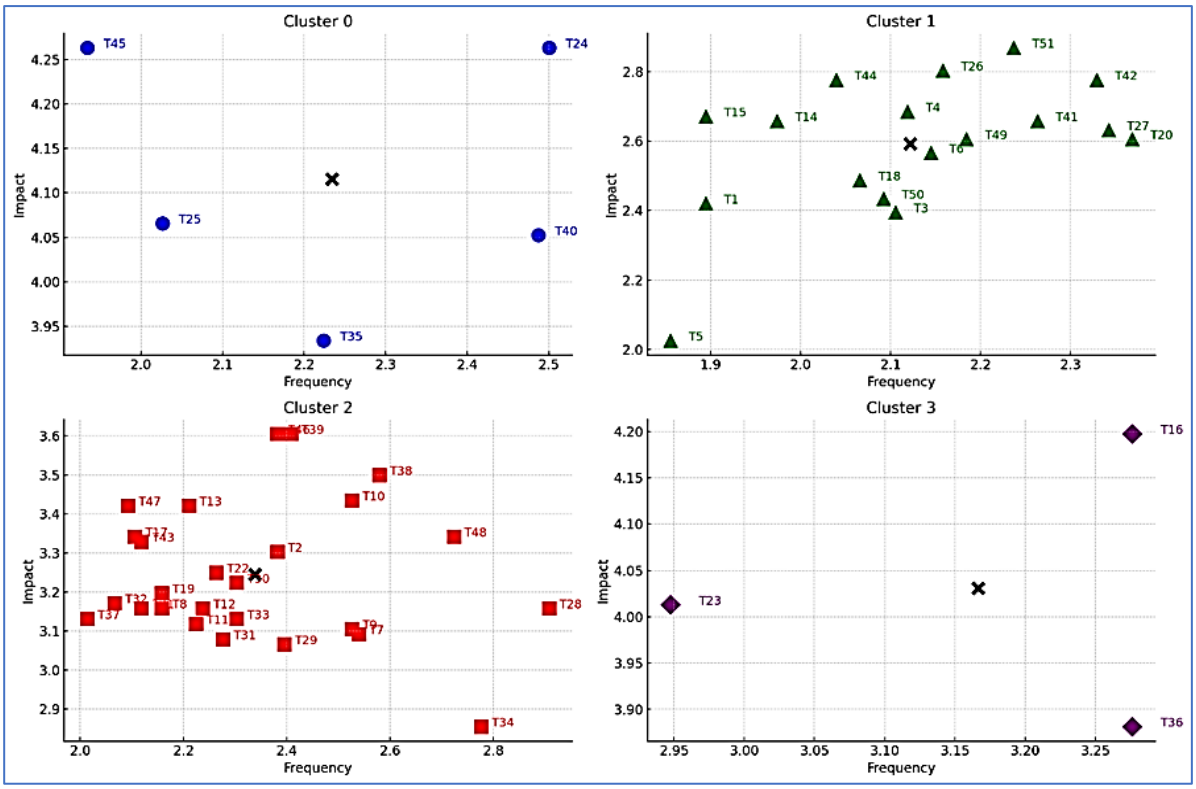

Figure 7. Assigned Causes of Claims for the Four Analyzed K-Means Clusters.

6. Conclusions

6.1. Frequent Types of Variations and Claims

Using the types and causes, RII was applied to construction industry workers in this research. Fifty-one types of variations and claims have been identified in section 1-part two based on a questionnaire survey of 80 respondents. These 51 significant types have been ranked according to respondents' perceptions, and the top ten are frequent and severe types.

Thus, these types require managerial attention and focus to avoid their frequencies, consequently providing positive benefits in managing construction projects, Table 13.

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Table 13. Causes of Claims and Variations.

No.	Significant Causes of Variations and Claims	No.	Avoidable Causes of Variations and Claims
01	Changes by Client (C21)	01	Inappropriate Contractor Selection (C10)
02	Inappropriate Contractor Selection (C10)	02	Inappropriate Payment Method (C13)
03	Inappropriate Contract Type (Strategy) (C05)	03	Inappropriate Contract Form (C06)
04	Inappropriate/ Unexpected Time Control (Target) (C15)	04	Inappropriate Contract Type (Strategy) (C05)
05	Inappropriate/ Unexpected Cost Control (Target) (C16)	05	Inadequate/Inaccurate Design Information (C01)
06	Lack of Information for Decision Making; (Decisiveness) (C19)	06	Inadequate Site Investigation (C24)
07	Inappropriate/ Unexpected Quality Control (Target) (C17)	07	Unclear & Inadequate Specifications (C04)
08	Slow Client Response (C20)	08	Inadequate Design Documentation (C02)
09	Inadequate/ Inaccurate Design Information (C01)	09	Inadequate Contract Documentation (C08)
10	Inappropriate Contract Form (C06)	10	Inadequate Contract Administration (C07)

6.2. Concluding Remarks

Based on the presented results, it is recommended that contract clauses dealing with such issues be given special consideration. The best way to cope with the risk of construction variations and claims is to reduce or avoid them altogether.

Certain fundamental ways and methods can reduce the number of encountered variations and claims (see Appendix A).

6.3. Comparative analysis and correlations summary

The Kruskal-Wallis test in Appendix B shows that project-related issues vary by respondent characteristics. For example, "a failure to rectify defects" has a significant variation based on personal experience (PC03) with a p-value of 0.030, suggesting that people with different experience levels perceive this issue differently. The firm's experience (PC04) and number of employees (PC06) also significantly affect "termination initiated by the contractor" (p-values of 0.039 and 0.004, respectively). These findings emphasize the importance of personal and organizational experience in addressing frequent project failures and contractor actions. Appendix C examines ways causes affect project outcomes. The Kruskal-Wallis test finds several significant results. For example, "failure to pay the agreed amount due" differs by respondents' role (PC01) and firm experience (PC04), with p-values of 0.007 and 0.012, respectively. Additionally, "delayed drawings or instructions" significantly affect the firm's number of projects (PC05) and employees (PC06), with p-values of 0.009 and 0.032. These findings suggest that financial issues and communication delays can significantly affect project performance, highlighting managerial improvement opportunities. The agreement analysis in Appendix D uses the Kruskal-Wallis test to identify significant causes of project issues. "Inadequate design" and "inadequate brief," with p-values of 0.008 and 0.007, respectively, significantly affect employee numbers (PC06). With a 0.000 p-value, "unclear and inadequate specifications" are significant for the firm's experience (PC04).

The significance analysis in Appendix E shows how causes affect project outcomes. With p-values of 0.012 and 0.001, "inadequate/inaccurate design" and "inappropriate contract type" affect the firm's number of projects (PC05) and employees (PC06). With a p-value of 0.002, "inadequate contract administration" negatively impacts project outcomes, particularly employee numbers (PC06). These findings emphasize the importance of accurate design information and contract management for project success and problem mitigation. The Kruskal-Wallis test in Appendix F shows factors related to project issue avoidability. With a p-value of 0.032, "inadequate design" affects the firm's experience (PC04), suggesting that better design processes could prevent related issues. "Inappropriate contact form" significantly affects respondents (PC01) and personal experience (PC03), with p-values of 0.011 and 0.223.

Appendix G examines variation/claim frequency and cause relationships using Spearman's correlation. Strong correlations exist between "changes by the client" and "delayed drawings or instructions" ($r = .397$, $p < 0.001$) and "inappropriate contractor selection" and "delayed payments" (r

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=.411, p < 0.001). The interconnectedness of project variations and their causes suggests that addressing root causes could reduce related claims. Appendix H uses Spearman's correlation to examine variations/claims and their causes. Significant correlations link "changes by the client" to "loss or damage to the works caused by employer's risks" (r =.447, p < 0.001) and "inappropriate contractor selection" to "client breach of contract" (r =.417, p < 0.001). These findings demonstrate the importance of strategic risk management because specific causes can significantly affect project outcomes. Appendix I examines project issue avoidability and variation/claim correlations. Significant correlations include "inappropriate payment method" and "acceleration of works" (r =.334, p = 0.003) and "inadequate site investigation" and "ambiguous documents" (r =.250, p = 0.029). These correlations suggest better payment methods and site investigations could prevent related project issues. Appendix J compares impactful variations/claims to avoidability causes. Significant correlations exist between "inappropriate contractor selection" and "client's breach of contract" (r =.307, p = 0.007) and "inadequate contract documentation" and "loss or damage to the works caused by employer's risks" (r =.310, p).

In conclusion, Kruskal-Wallis's test and Spearman's correlation analysis across appendices reveal how respondent roles, personal and organizational experience, and project causes affect project variation and claim frequency, impact, agreement, and avoidability.

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Appendix A. Guidelines & Techniques to Control Significant and Avoidable Causes of Claims and Variations

#	Avoidable Causes of Variations and Claims	Recommended Mitigation/ Response Strategy
1	**Changes by Client (C21)**	• Ensure that the Project brief is comprehensive & Clear / Ensure agreement on the project brief • Ensure the early discussion with other authorities to anticipate their requirements • Spend adequate time in project planning • Ensure & Approve the full Development & Coordination of the design • Identify allocated risks & adopt suitable criteria like value for money to evaluate & manage risk • Adopt change control procedures & try to minimize changes as possible.
2	**Inappropriate Contractor Selection (C10)**	• Selection of the contractor should be based on a set of multiple decision criteria; both price and non-price related. • Consider financial ability, past performance, experiences and key personnel availability. • Consider contractor's current workload, past experience in terms of size of completed projects, management resources in terms of formal training regime, past performance. • Consider technical ability, management capability, and health and safety performance. • Consider Contractor's reputation including claims & Disputes.
3	**Contract Type/ Strategy - C05**	• (Feasibility) Link strategic business goals to initial project goals and justify facility. • (Concept) Translate the business objectives to initial scope of work and select alternatives (project delivery, contracting). • (Detailed Scope) Design decisions and delivery & contracting strategy. • (Design) Full determined project delivery & contracting strategy and control plans. • (Construction) Explain construction methodology, operations, contracting strategy and procedures. • (Commissioning, start-up & operate) Finalize commissioning, start-up and update operations contracts and handover of operations. • Consider attributes of optimal contracts: - Align (owner and contractor) objectives - Value for money contractor - Quality (valued or truthful) Information/ Trust and Relationship management Long term commitment and renegotiation/ - Optimal risks sharing. - Optimal wage scheduling/ optimal incentive contracting.
4	**Inappropriate/ Unexpected Time Control (Target)-(C15)**	• Establish Schedule Control Procedures/System • Establish a Time Border : by fixing the overall project duration either by specific constraints or by contract strategy to use it as a key parameter • Assure Time Auditing System : Monitor actual time spent on each activity against planned time • In case of any exceeds of time allowance: - Allow the re-sequencing of later activities - Allow the shortening of time by increasing the resource (Crashing will result in extra cost) - Allow the program for the time impacts of identified risks occurring - Assess & Revise Contractor's Program of Work
5	**Inappropriate/ Unexpected Cost Control (Target)- C16**	• Run efficient planning of strategies and management of site and supervision of the project. • Keep organized regulatory mechanism; and using proper methods for construction, the organizational strategies include: - Appropriate prominence on previous experience; - Regular coordination between the associated parties; - Increasing human resources in the industry; and - Conduct administration of contracts - Regular meetings on development, - Employ proficient subcontractors and suppliers, attributing less weight to prices, and more weight to abilities and earlier performance of contractors to improve the contracts and their reactive and organizational strategies/ procedures. • Use channels for perfect information and communication. • Utilization of latest technology is a proactive and reactive strategy. • Undertake a preconstruction planning regarding the procedures and resources of project.
6	**Lack of Information for Decision-Making; Decisiveness-(C19)**	• Define and clarify the issue - does it warrant action? If so, now? Is the matter urgent, important or both? • Gather all the facts and understand their causes. • Think about or brainstorm possible options and solutions. • Consider and compare the 'advantages and disadvantages ' of each option - consult others if necessary or useful - and for bigger complex decisions where there are several options, create a template which enables measurements according to different strategic factors. • Select the best option - avoid vagueness and weak compromises in trying to please everyone. • Explain your decision to those involved and affected, and follow up to ensure proper and effective implementation.

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7	**Inappropriate /Unexpected Quality Control (Target)-(C17)**	• Improve interactions and processes between the Project knowledge areas • Ensure project objectives are met • Reduce expenses due to avoidance of mistakes • Less rework is necessary which leads to save time • Result in better working conditions and wellbeing of the workforce • Improve communication between team members through well-defined processes • Lead to good quality of products as it becomes a company minimal requirement
8	**Slow Client Response- (C20)**	• Develop Project Monitoring Mechanism • Establish regular Meetings. • Seek assistance to obtain information from others and experts to expedite the response.
9	**Inadequate/ Inaccurate Design Information- (C01)**	• Planning: Describe who does what, when, at what cost & with what specification? • Final Design Kick-Off Meeting to review: Project requirements; Project Schedule; All Project significant Decisions & Assure that all parties clearly understand issues indicated by the approved Preliminary Design • Assure Completeness of All Drawings & fully define the work as required. • Assure Coordination of All Drawings with the specifications required. • Incorporate all Adjustments as per the approved design drawings. • All Drawings should be Drafted Clearly. • Include all Composite Drawings for clarifications. • Assure inclusion of Borings & other subsurface / Geotechnical information in the drawings. • Use Graphic & Alphanumeric Scales to avoid confusion on reduced prints & appropriate drafting scale and include symbols, legends and abbreviations. • Assure Preparation of Final Specifications including: Format of Specifications, Coordination of Specifications, Revision of final submission and commissioning specifications for HVAC, Plumbing & electrical system … • Insure Conformity of final Design Drawings & Specification with requirements in terms of: Drawing Format, Conformity with comments, Stamps, Signatures, Approvals of Regulatory Agency & clarity & Completeness of Specifications. • Insure the production & Review of Final Cost Estimate. • Develop, review & follow Final Design Procedures such as: submittal & Reviews; Utility & Regulatory Agency Approval; Resolution of Questions. • Prepare the Bid Form, General Condition & Special condition of contract, and include any contractor special experience requirements. • Conduct A Constructability Review to facilitate production of contract documents including technical Specification that are clear, coordinated and complete • Conduct a Design Review to plans, specifications, bid booklet &Addendums
10	**Inappropriate Contract Form- (C06)**	• The contract should describe the following: - What will be done/ How long it will take to complete/ How much it will cost and the payment terms; - What will be done if either party defaults; - The extent to which the common law, which would usually apply, is adhered to. • Determine the construction contract parties: - Employer: Requires the construction work and provides payment - Employer's Representative: Acts on behalf of the employer and may be referred to as engineer, project manager, principal agent, etc. - Contractor: Commissioned to construct the works - Subcontractor: Appointed by the contractor to perform a part of the construction works under a subcontract - Adjudicator/ Arbitrator/ Court: Settles disputes between the parties • Decide contract form: - Bespoke contract/ Standard form contracts • identify way of contracting: - Main contractor/ Joint venture partner/ Subcontractor • Decide Construction contract arrangement: - Pure construction contract/ Design-build/ Engineer, procure and construct • Define contract party's rights: - Timeous payments/ Extensions of time/ Access to site/ Upon termination of the contract/ Appointment of subcontractors • Draw contract party's responsibilities: - Completing works/ Guarantees / Insurances/ Administrative procedures/ compliance with all applicable laws - Response to communications/ Substantiation of claims/ Subcontracts • Balance contract party's risks: - Errors in calculations/ Poor management/ Delays/ Penalties/ Insolvency of employer
11	**Inappropriate Payment Method- (C13)**	• Define the stakeholders & supply chain • Identify project program • Define the project process mapping, Responsibility Assignment Matrix. • Define the products, services, management, design, engineering and prefab & assembly needed to a project. • Approve a common framework for managing and controlling project in order to meet the client's business needs.

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		• Refine and improve continually such processes (framework for managing and controlling). • Detail all the required actions that must be taken under the common framework of a process map. • Analyze such a detailed process map to simulate the payment requirements within design and construction stages in order to analyze the effect of using alternative payment mechanisms on the cash flow of the stakeholders and supply chain members. • Note that the concept of the stakeholders & supply chain is emerging as a significant performance enabler for construction industry. • After payment mechanism was defined, start plan your cash flow lifecycle, • Compare your payment mechanism with preferable forms of payment: • reimbursable cost-plus a percentage-fee/ reimbursable cost-plus a fixed-fee/ target cost (shared over-run and/or under run)/ unit-rate (including re-measure)/guaranteed maximum price/ lump-sum services and materials with reimbursable construction/ Lump-sum (i.e., wholly lump-sum)/ open-book accounting/ stage payments/ incentive contracting/ direct payment/ trust accounts/funds/ mobilization advance payment
12	**Inadequate Site Investigations- (C24)**	• Define building Design Concept/ Set Terms of Reference • Describe Preliminary Site Characterization • Test Holes and Sampling/ Test Hole Number and Depth/ Test Hole Stratigraphic Description and Sampling • Laboratory Testing/ Soil Classifications/ Take Photographs/ Ground Temperature Measurement • Determine Report including: - Restate project definition; - Characterize the site so that surrounding conditions that may impact on the design and performance of the building foundation are understood and designed for; - State the present and the projected end of the building service life, climate and ground temperatures; - Classify the soil strata according to recognized ASTM Standards, based on quantitative laboratory results; • Identify foundation options appropriate for the proposed service life of the building; and • Provide guidance for the construction scheduling of the foundation for the building/ Peer Review.
13	**Unclear & Inadequate Specifications- (C04)**	• Be aware of Different Type of Specifications including; Output Based, Performance or Prescriptive • Developing the Project Specifications According to; Scope of Users Requirement; Quality & Performance Characteristics; Technical Characteristics. • Apply Value Management • Proper Structuring of the Project Specifications • Assess the Whole Life Cost Implications of Specifications • Obtain Final Approval of the Specifications • Proper Coordination with other contract documents.
14	**Inadequate Design Documentation- (C02)**	• Establishment of well-defined client brief comprising key drivers and parameters such as: budgets, functions, quality, sustainability, urban issues and commercial returns. • Better articulation of requirements by the client equates to better consultant response. • Client brief to include any requirements for document checking and coordination. • Client may require additional advice in brief preparation, budgeting and programming and engage specialists' expertise, as in the case of highly complex projects. This may include engagement of facilities planners and/or independent cost advisors that may not necessarily be part of the project team. • Clearly articulate client expectations of the consultant in the request for proposal and state criteria for selection. • Clearly articulate the conditions of contract and obligations on the consultant i.e., quality control, assurances. • Consultant Selection based on technical abilities and past experiences in addition to financial offers. • Clients may insist on demonstrable quality control consultants. Consultant Obligations and Functions • Consultants to articulate the project methodologies including design approaches and quality controls in response to invitations to submit proposals. • Primary consultants should select any secondary consultants on a value for money basis and submit with their proposals the rationale for selection of their consultant team. • Team Formation and Project Integration • At the commencement of the project, client and project team should ensure that roles, responsibilities and obligations of all parties are clearly understood. • Establish and agree a design and documentation review process including review points and agree milestones for client and project team sign-off. • Develop a quality plan including procedures for communication, document control and coordination. • Client may create obligations on consultants to report on risk and options for managing risk. • Obtain approvals and sign off progressively throughout the project. • Encourage project teams and clients to utilize tools to assist e.g., value management. • Encourage establishment of integrated teams and articulate procedures for problem resolution. • Encourage design and documentation teams to bring construction expertise to the team to provide greater confidence e.g., early use of contractors on build-ability decisions. • Quality Management Incorporating Project Implementation, Design and Documentation. • Actively consider total cost of project (over the life cycle) as part of the design and documentation process. • Develop a range of Quality Management Tools including checklists, review procedures and audit processes. • The client and project team to consider the role of independent reviewer or value management.

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		• Consultants to provide advice on the quality of documentation that could be reasonably expected from the agreed resources allocated and timelines established for the period. • Consultants to warrant that they have undertaken the design and documentation consistent with the quality plan. • Use of technology by consultants to assist in documentation control and coordination. • Project team to agree upon and nominate an experienced person responsible for documentation coordination. • Obtain approvals and segmental sign off. • Advise the client on the adequacy of the brief and the risks associated with any inadequate allowance for proper documentation in both budgets and programs. • Coordinate secondary consultants, obtain their sign-off on completeness of their documentation, and provide overall sign-off to the client that project documentation is comprehensive. • Ensure version control of documents to secondary consultants. • Create design and documentation coordination roles within project team.
15	**Inadequate Contract Documentation-(C08)**	• Clearly Define Contract Documentations • Assure that the Contract conveys a clear Understanding of the Scope of the Project • Carefully Define the Responsibilities, Authorities, Roles & line of Communications of the contract parties • Develop & Monitor progress according to preset monitoring • Assure adequacy & accuracy of Design Information • Assure adequacy & accuracy& Consistency of Tender Information • Conduct Constructability Review • Review Contract Documentation for consistency & clear ambiguities before tendering • Correct ambiguities & Inconsistencies when discovered during tender stage by issuing addenda • Use Clear words when defining terms especially the terms “Works” & “Approved • Carefully draft the definitions section of the contract • Assure Completion of all final contract Documentation.
16	**Inadequate Contract Administration-(C07)**	• Project Management Discipline: All work to be performed should be appropriately led, planned, scheduled, coordinated, communicated, tracked, evaluated, reported and corrected, as necessary. • Contract Analysis and Planning: Before contract award, each party should develop a contract administration plan and assign the responsibility of administering the contract to a contract manager. • Kick-off Meeting or Pre-performance Conference: Before performance begins. • Performance Measuring and Reporting: During contract performance; the project manager, contract manager, and responsible business managers all must observe performance, collect information, and measure actual progress. • Payment Process: Every contract must establish a clear invoicing and payment process. • Contract Change Management Process: As a rule, any party that can make a contract can agree to change it. Changes are usually inevitable in contracts for complex undertakings. • Dispute Resolution Process. • Contract Closeout Process: Contract closeout refers to verification that all administrative matters are concluded on a contract that is otherwise physically complete.
17	**Incomplete Tender Information-(C09)**	• Perform careful review/audit of all tender documents prior to tendering to avoid ambiguities & discrepancies • Assure Clarity, consistency & completeness • Adequate information for Solicitation such as: Project brief; place of collecting & reviewing bids; bid security requirements; bid due date, time & location • Ensure adequate Instructions’ information to bidders such as: Type of bid; Preparation of the bid; bid bonds & Security; Permits; bid’s opening • Arrange a Pre-tender site visit for potential bidders • Ensure adequate bid Response forms’ information such as: Project Identification; To whom the bid is directed; Person submitting the bid; validity of the bid Acknowledgments; Pricing; Start & completion date • Provide Specifications; Drawings; Contract forms; General & Specific Conditions & Bill of Quantities • Identify the award Criteria and the essential requirements of a complete bid • Clarify areas of concerns within the tender document • Send all clarified questions and answer, to all bidders • Avoid all unofficial communication with bidders • All communication should be in writing. • Make a written notice of award after the evaluation • Keep accurate records of the tender process in case.

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Appendix B. Kruskal Wallis test and p-value (Types of variations and claims – in terms of Frequency)

Code	Type	Role of the Respondents (PC01)		Managerial Level (PC02)		Personal Experience (PC03)		Organization/ Firm's Experience (Years) (PC04)		Organization/ Firm's Annual Number of Projects (PC05)		Organization/ Firm's Number of Employees (PC06)	
		Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)
T12	A failure to rectify defects	3.757	0.153	0.880	0.644	10.716	0.030	.0.27	0.866	1.495	0.828	1.233	0.873
T14	Contractor's failure to insure	0.389	0.823	1.935	0.380	4.351	0.361	12.058	0.017	6.596	0.159	2.853	0.583
T16	Delayed drawings or instructions	0.741	0.690	2.696	0.260	1.402	0.844	13.614	0.009	6.451	0.168	1.103	0.894
T36	**Termination initiated by the contractor**	**5.676**	**0.059**	**2.776**	**0.250**	**3.372**	**0.498**	**10.077**	**0.039**	**2.345**	**0.673**	**15.413**	**0.004**
T39	Loss or damage to the works caused Employer's Risks	1.232	0.540	0.949	0.622	6.340	0.175	7.578	0.108	14.220	0.007	6.147	0.188

Appendix C. Kruskal Wallis test and p-value (Types of variations and claims – in terms of Impact)

Code	Type	Role of the Respondents (PC01)		Managerial Level (PC02)		Personal Experience (PC03)		Firm's Experience in business) (PC04)		Firm's Annual Number of Projects (PC05)		Firm's Number of Employees (PC06)	
		Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)
T02	Failure to pay agreed amount due.	9.810	**0.007**	0.853	0.653	5.711	0.222	12.868	**0.012**	1.668	0.797	0.941	0.919
T11	Failed tests on completions	12.143	**0.002**	0.980	0.613	1.286	0.864	11.567	**0.021**	4.106	0.392	1.291	0.863
T16	**Delayed drawings or instructions**	**4.236**	**0.120**	**1.286**	**0.526**	**6.177**	**0.186**	**5.823**	**0.213**	**13.615**	**0.009**	**10.538**	**0.032**
T21	Fossils, archaeological or geological	6.722	**0.035**	0.806	0.668	0.793	0.939	7.127	0.129	1.836	0.766	4.559	0.336
T22	Additional tests by the engineer	4.437	0.109	6.532	**0.038**	4.671	0.323	1.841	0.765	3.470	0.482	1.201	0.878
T25	Shortage of personnel or goods	4.334	0.115	6.174	**0.046**	6.841	0.145	2.121	0.713	2.726	0.605	1.870	0.760
T26	**Employer's delay or impediment**	**2.120**	**0.346**	**4.185**	**0.123**	**0.414**	**0.981**	**1.632**	**0.803**	**2.038**	**0.729**	**10.035**	**0.040**
T27	Delays caused by authorities	6.376	**0.041**	1.003	0.606	1.882	0.757	4.640	0.326	11.746	0.019	5.343	0.254
T29	Employer using works partially	0.105	0.949	7.149	**0.028**	3.864	0.425	4.435	0.350	5.405	0.248	2.994	0.559
T32	Adopt value engineering proposal	2.326	0.312	7.327	**0.026**	0.248	0.993	2.123	0.713	3.247	0.517	0.491	0.974
T38	Ambiguity in Documents	6.357	**0.042**	0.663	0.718	2.917	0.572	1.028	0.906	0.964	0.915	4.404	0.354
T39	Loss or damage to the works caused Employer's Risks	3.103	0.212	2.344	0.310	5.551	0.235	3.117	0.538	12.596	0.013	9.185	0.057
T43	Refusal of contractor objection to nomination	6.020	**0.049**	2.210	0.331	6.101	0.192	3.929	0.416	2.498	0.645	1.374	0.849
T45	Acceleration of Works	6.446	**0.040**	1.929	0.381	7.492	0.112	4.239	0.375	3.131	0.536	2.153	0.708
T47	**Client's Breach of Contract**	**4.435**	**0.109**	**0.294**	**0.863**	**1.745**	**0.783**	**5.417**	**0.247**	**8.780**	**0.067**	**10.051**	**0.040**
T49	Currency Fluctuation	10.413	**0.005**	2.801	0.246	9.776	**0.044**	6.154	0.188	2.455	0.653	3.481	0.481

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Appendix D. Kruskal Wallis test and p-value (Types of variations and claims – in terms of agreement)

Code	Cause	Role of the Respondents (PC01)		Managerial Level (PC02)		Personal Experience (PC03)		Organization/ Firm's Experience (PC04)		Organization/ Firm's Annual Number of Projects (PC05)		Organization/ Firm's Number of Employees (PC06)	
		Kruskal-Wallis H	.(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	(P-Value)	Kruskal-Wallis H	.(P-Value)	Kruskal-Wallis H	.(P-Value)	Kruskal-Wallis H	.(P-Value)
C02	**Inadequate Design.**	**1.221**	**0.543**	**2.181**	**0.336**	**5.071**	**0.280**	**4.855**	**0.303**	**6.433**	**0.169**	**13.818**	**0.008**
C03	**Inadequate Brief**	**0.997**	**0.608**	**0.045**	**0.978**	**4.924**	**0.295**	**9.823**	**0.044**	**12.967**	**0.011**	**14.055**	**0.007**
C04	Unclear & Inadequate Specs.	4.941	0.085	1.826	0.401	2.462	0.651	21.749	**0.000**	5.655	0.226	5.367	0.252
C05	Inappropriate Contract Type	2.773	0.250	1.178	0.555	7.109	0.130	7.520	0.111	16.349	**0.003**	4.917	0.296
C06	**Inappropriate Contract Form**	**2.015**	**0.365**	**2.237**	**0.327**	**6.817**	**0.146**	**20.442**	**0.000**	**17.144**	**0.002**	**14.043**	**0.007**
C07	Inadequate Contract Administration	5.267	0.072	1.334	0.513	2.020	0.732	14.674	**0.005**	4.553	0.336	0.854	0.931
C08	Inadequate Contract Documents	2.433	0.296	2.508	0.285	8.510	0.075	18.180	**0.001**	8.729	0.068	9.314	0.054
C09	**Incomplete Tender Information**	**1.577**	**0.455**	**0.046**	**0.977**	**5.389**	**0.250**	**6.898**	**0.141**	**11.187**	**0.025**	**11.288**	**0.024**
C10	Inappropriate Contractor Selection	2.707	0.258	3.805	0.149	10.949	0.027	15.995	0.003	7.654	0.105	6.037	0.196
C11	**Unrealistic Tender Pricing**	**2.557**	**0.278**	**3.768**	**0.152**	**13.541**	**0.009**	**13.012**	**0.011**	**12.290**	**0.015**	**11.334**	**0.023**
C12	Unrealistic Client Expectations	3.224	0.199	2.811	0.245	14.404	0.006	14.668	0.005	15.187	0.004	7.866	0.097
C13	**Inappropriate Payment Method**	**4.218**	**0.121**	**1.526**	**0.466**	**6.919**	**0.140**	**10.975**	**0.027**	**9.080**	**0.059**	**16.076**	**0.003**
C14	**Inappropriate Document Control**	**2.581**	**0.275**	**1.700**	**0.427**	**11.051**	**0.026**	**15.091**	**0.005**	**7.038**	**0.134**	**16.094**	**0.003**
C16	**Inappropriate/ Unexpected Cost Control (Target)**	**2.024**	**0.364**	**1.731**	**0.421**	**7.469**	**0.113**	**5.733**	**0.220**	**5.949**	**0.203**	**13.823**	**0.008**
C17	**Inappropriate/ Unexpected Quality Control (Target)**	**4.758**	**0.093**	**0.106**	**0.948**	**8.535**	**0.074**	**11.844**	**0.019**	**9.188**	**0.057**	**19.021**	**0.001**
C18	**Poor Communications**	**3.506**	**0.173**	**0.358**	**0.836**	**6.813**	**0.146**	**4.159**	**0.385**	**2.665**	**0.615**	**13.069**	**0.011**
C19	**Lack of (Decisiveness)**	**1.221**	**0.543**	**0.804**	**0.669**	**11.500**	**0.021**	**7.138**	**0.129**	**7.686**	**0.104**	**10.905**	**0.028**
C20	**Slow Client Response**	**3.472**	**0.176**	**4.648**	**0.098**	**11.252**	**0.024**	**11.589**	**0.021**	**8.602**	**0.072**	**13.742**	**0.008**
C21	Changes by Client	3.959	0.138	1.537	0.464	6.285	0.179	9.489	0.050	5.426	0.246	4.777	0.311
C24	**Inadequate Site Investigations**	**0.464**	**0.793**	**0.011**	**0.995**	**6.324**	**0.176**	**9.965**	**0.041**	**7.853**	**0.097**	**23.056**	**0.000**
C25	**Unrealistic Expectations (By the Contractor)**	**2.574**	**0.276**	**0.726**	**0.696**	**6.848**	**0.144**	**10.994**	**0.027**	**11.313**	**0.023**	**19.155**	**0.001**
C27	**Personality Clashes of Participants**	**2.463**	**0.292**	**0.866**	**0.648**	**5.909**	**0.206**	**9.581**	**0.048**	**9.259**	**0.055**	**25.707**	**0.000**
C28	**Poor Management By Participants**	**0.738**	**0.692**	**0.047**	**0.977**	**8.442**	**0.077**	**10.064**	**0.039**	**5.525**	**0.238**	**13.343**	**0.010**
C29	**Adversarial Cultural Affairs**	**2.141**	**0.343**	**0.640**	**0.726**	**6.980**	**0.137**	**13.252**	**0.010**	**9.925**	**0.042**	**19.660**	**0.001**
C30	**Uncontrollable External Events**	**1.213**	**0.545**	**0.857**	**0.651**	**11.095**	**0.026**	**7.143**	**0.129**	**3.248**	**0.517**	**10.913**	**0.028**
C31	Exaggerated Claims	7.108	0.029	1.228	0.541	7.047	0.133	7.527	0.111	7.732	0.102	4.664	0.324

Appendix E. Kruskal Wallis test and p-value (Types of variations and claims – in terms of significance)

Code	Cause	Role of the Respondents (PC01)		Managerial Level (PC02)		Personal Experience (PC03)		Organization/ Firm's Experience (Firm's Number of Years) (PC04)		Organization/ Firm's Annual Number of Projects (PC05)		Organization/ Firm's Number of Employees (PC06)	
		Kruskal-Wallis H	P-Value	Kruskal-Wallis H	P-Value	Kruskal-Wallis H	P-Value	Kruskal-Wallis H	P-Value	Kruskal-Wallis H	P-Value	Kruskal-Wallis H	P-Value
C01	Inadequate/ Inaccurate Design	8.92	**0.012**	0.372	0.830	2.069	0.723	4.038	0.401	12.699	**0.013**	8.493	0.075
C03	Inadequate Brief	9.09	**0.01**	1.894	0.388	7.387	0.117	7.114	0.130	3.263	0.515	6.746	0.150
C04	Unclear & Inadequate Specifications	5.04	0.080	2.802	0.246	11.111	**0.025**	12.551	**0.014**	6.064	0.194	7.515	0.111
C05	**Inappropriate Contract Type**	**6.95**	**0.031**	**0.702**	**0.704**	**7.852**	**0.097**	**7.395**	**0.116**	**12.882**	**0.012**	**18.944**	**0.001**
C06	**Inappropriate Contract Form**	**3.002**	**0.223**	**2.110**	**0.348**	**5.036**	**0.284**	**3.565**	**0.468**	**9.563**	**0.048**	**11.976**	**0.018**

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C07	**Inadequate Contract Administration**	**8.91**	**0.012**	**0.579**	**0.749**	**3.059**	**0.548**	**4.436**	**0.350**	**7.796**	**0.099**	**17.400**	**0.002**
C08	**Inadequate Contract Docs.**	**1.83**	**0.400**	**2.267**	**0.322**	**4.009**	**0.405**	**4.619**	**0.329**	**4.800**	**0.308**	**12.948**	**0.012**
C09	Incomplete Tender Information	6.14	**0.046**	2.411	0.300	6.970	0.138	7.981	0.092	3.713	0.446	4.670	0.323
C10	**Inappropriate Contractor Selection**	**2.00**	**0.367**	**2.025**	**0.363**	**10.113**	**0.039**	**8.103**	**0.088**	**13.516**	**0.009**	**16.415**	**0.003**
C11	**Unrealistic Tender Pricing**	**6.71**	**0.035**	**0.233**	**0.890**	**8.069**	**0.089**	**11.710**	**0.020**	**2.540**	**0.637**	**8.474**	**0.076**
C12	**Unrealistic Client Expectations**	**9.49**	**0.009**	**1.183**	**0.554**	**1.880**	**0.758**	**5.153**	**0.272**	**5.957**	**0.202**	**9.015**	**0.061**
C13	**Inappropriate Payment Method**	**4.63**	**0.099**	**0.846**	**0.655**	**3.483**	**0.480**	**2.253**	**0.689**	**7.175**	**0.127**	**12.042**	**0.017**
C14	Inappropriate Document Control	1.72	0.421	0.108	0.947	4.141	0.387	1.238	0.872	5.515	0.238	4.552	0.336
C15	**Inappropriate/ Unexpected Time Control (Target)**	**7.34**	**0.025**	**0.011**	**0.995**	**7.869**	**0.096**	**7.247**	**0.123**	**14.352**	**0.006**	**21.28**	**0.000**
C16	**Inappropriate/ Unexpected Cost Control (Target)**	**4.14**	**0.126**	**1.456**	**0.483**	**5.846**	**0.211**	**5.821**	**0.213**	**10.956**	**0.027**	**13.44**	**0.009**
C17	**Inappropriate/ Unexpected Quality Control (Target)**	**4.85**	**0.088**	**2.925**	**0.232**	**5.286**	**0.259**	**7.227**	**0.124**	**7.661**	**0.105**	**21.705**	**0.000**
C18	Poor Communications	6.59	**0.037**	1.379	0.502	3.132	0.536	10.064	**0.039**	3.327	0.505	2.739	0.602
C19	**Lack of Decisiveness**	**4.63**	**0.099**	**2.345**	**0.310**	**3.896**	**0.420**	**4.594**	**0.332**	**8.482**	**0.075**	**15.25**	**0.004**
C20	Slow Client Response	10.96	**0.004**	0.819	0.664	9.864	**0.043**	4.353	0.360	16.149	**0.003**	6.914	0.140
C21	**Changes by Client**	**4.271**	**0.118**	**1.245**	**0.536**	**6.882**	**0.142**	**7.331**	**0.119**	**13.584**	**0.009**	**15.214**	**0.004**
C23	Poor Workmanship	7.948	**0.019**	0.668	0.716	3.692	0.449	7.843	0.098	4.764	0.312	1.142	0.888
C24	**Inadequate Site Investigation**	**0.837**	**0.658**	**0.320**	**0.852**	**1.904**	**0.753**	**8.113**	**0.088**	**5.419**	**0.247**	**12.387**	**0.015**
C28	Poor Management	6.953	**0.031**	0.240	0.887	8.590	0.072	3.515	0.476	2.022	0.732	6.483	0.166
C29	**Adversarial Cultural Affairs**	**15.06**	**0.001**	**0.075**	**0.963**	**4.051**	**0.399**	**7.528**	**0.110**	**10.968**	**0.027**	**10.025**	**0.040**

Appendix F. Kruskal Wallis test and p-value (Types of variations and claims – in terms of avoid ability)

Code	Cause	Role of the Respondents (PC01)		Managerial Level (PC02)		Personal Experience (PC03)		Organization/ Firm's Experience (Firm's Number of Years) (PC04)		Organization/ Firm's Annual Number of Projects (PC05)		Organization/ Firm's Number of Employees (PC06)	
		Kruskal-Wallis H	**(P-Value)**	**Kruskal-Wallis H**	**(P-Value)**	**Kruskal-Wallis H**	**(P-Value)**	**Kruskal-Wallis H**	**(P-Value)**	**Kruskal-Wallis H**	**(P-Value)**	**Kruskal-Wallis H**	**(P-Value)**
C02	Inadequate Design	0.336	0.845	0.989	0.610	3.995	0.407	10.590	**0.032**	9.109	0.058	2.490	0.646
C06	Inappropriate Contract Form	9.055	**0.011**	5.086	0.079	5.691	0.223	11.693	**0.020**	6.923	0.140	6.264	0.180
C08	Inadequate Contract Documents	8.158	**0.017**	1.232	0.540	3.889	0.421	1.588	0.811	2.193	0.700	5.175	0.270
C09	Incomplete Tender Information	2.093	0.351	2.717	0.257	13.175	**0.010**	4.111	0.391	1.753	0.781	2.316	0.678
C10	Inappropriate Contractor Selection	2.769	0.250	2.121	0.346	9.798	**0.044**	1.463	0.833	3.212	0.523	2.881	0.578
C13	**Inappropriate Payment Method**	**1.031**	**0.597**	**0.153**	**0.927**	**5.576**	**0.233**	**10.797**	**0.029**	**7.427**	**0.115**	**13.673**	**0.008**
C21	Changes by Client	6.743	**0.034**	4.693	0.096	1.210	0.876	1.191	0.880	2.101	0.717	5.204	0.267
C30	Uncontrollable External Events	0.378	0.828	1.468	0.480	10.300	**0.036**	2.847	0.584	2.727	0.604	3.585	0.465

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Appendix G. Spearman coefficients and p-values between the most frequented: types of variations/claims and causes

TYPE (Frequency)			T16	T23	T38	T45	T31	T34	T25	T07	T09	T10
CAUSE (SIGNIFICANCE)	Correlation (Coefficients)		Delayed drawings or instructions	A variation or significant change to the quantities	Ambiguity in Documents	Acceleration of Works	An omission of work forming	Delayed payments	Shortage of personnel or goods	Rejection of defective plant and / or materials	Revised methods of working due to slow progress	Delay damages
C21	Changes by Client	Correlation	**.397****	.242*	.280*	.148	.366**	.046	.033	.054	-.025	.114
		Sig. (2-tailed)	.000	.035	.014	.202	.001	.694	.780	.644	.830	.325
C10	Significance Inappropriate Contractor Selection	Correlation	**.346****	.279*	.236*	.126	.411**	.018	.070	-.002	-.005	.179
		Sig. (2-tailed)	.002	.015	.041	.277	.000	.880	.546	.984	.969	.122
C05	Significance Inappropriate Contract Type (Strategy)	Correlation	**.291***	.328**	.251*	.102	.460**	.034	-.038	.066	.049	.140
		Sig. (2-tailed)	.011	.004	.028	.382	.000	.768	.742	.574	.674	.227
C15	Significance Inappropriate/ Unexpected Time Control	Correlation	**.229***	.258*	.146	.135	.320**	.037	-.005	.140	.093	.187
		Sig. (2-tailed)	.046	.025	.209	.244	.005	.748	.968	.229	.423	.106
C16	Significance Inappropriate/ Unexpected Cost Control	Correlation	**.268***	.306**	.133	.220	.426**	.157	.084	.200	.204	.240*
		Sig. (2-tailed)	.019	.007	.253	.056	.000	.175	.472	.083	.078	.037
C19	Significance Lack of Decisiveness	Correlation	**.320****	.333**	.179	.266*	.426**	.019	-.036	.125	.147	.119
		Sig. (2-tailed)	.005	.003	.123	.020	.000	.868	.760	.281	.206	.306
C17	Significance Inappropriate/ Unexpected QC (Target)	Correlation	**.304****	.250*	.142	.077	.297**	.021	-.085	.051	.039	.096
		Sig. (2-tailed)	.008	.029	.223	.507	.009	.855	.463	.662	.736	.408
C20	Significance Slow Client Response	Correlation	**.389****	.321**	.334**	.099	.457**	.211	.132	.142	-.016	.196
		Sig. (2-tailed)	.001	.005	.003	.393	.000	.067	.256	.222	.890	.089
C01	Significance Inadequate/ Inaccurate Design Information	Correlation	**.297****	.192	.237*	.062	.317**	.177	.168	.236*	.240*	.207
		Sig. (2-tailed)	.009	.096	.039	.595	.005	.127	.146	.040	.037	.073
C06	Significance Inappropriate Contract Form	Correlation	**.263***	.291*	.265*	.197	.440**	.259*	.004	-.015	-.025	.246*
		Sig. (2-tailed)	.022	.011	.021	.088	.000	.024	.975	.897	.827	.032

Appendix H. Spearman coefficients and p-value between frequented: Types of variations/claims and causes.

TYPE (Impact)			T39	T47	T16	T41	T27	T38	T33	T23	T26	T48
CAUSE (SIGNIFICANCE)	Correlation (Coefficients)		Loss or damage to the works caused Employer' s Risks	Client' s Breach of Contract	Delayed drawings or instructions	Force Majeure	Delays caused by authorities	Ambiguity in Documents	Changes in legislation	A variation or change of quantities	Employer' s delay or impediment	Inflation / Price Escalation
C21	Changes by Client	Correlation	**.447****	.424**	.470**	.389**	.548**	.468**	.529**	.252*	.392**	.136
		Sig. (2-tailed)	.000	0.000	.000	.001	.000	.000	.000	.028	.000	.240
C10	Inappropriate Contractor Selection	Correlation	**.559****	.417**	.385**	.462**	.595**	.490**	.432**	.174	.479**	.189
		Sig. (2-tailed)	.000	.000	.001	.000	.000	.000	.000	.133	.000	.102
C05	Inappropriate Contract Type	Correlation	**.501****	.481**	.433**	.438**	.560**	.507**	.542**	.295**	.457**	.276*
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.010	.000	.016
C15	Inappropriate/ Unexpected Time Control	Correlation	**.461****	.492**	.487**	.398**	.581**	.391**	.410**	.256*	.383**	.313**
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.026	.001	.006
C16	Inappropriate/ Unexpected Cost Control	Correlation	**.438****	.453**	.453**	.390**	.539**	.469**	.519**	.345**	.357**	.136
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.002	.002	.243
C19	Lack of Information for (Decisiveness)	Correlation	**.556****	.561**	.377**	.309**	.538**	.448**	.486**	.207	.462**	.336**
		Sig. (2-tailed)	.000	.000	.001	.007	.000	.000	.000	.073	.000	.003
C17	Inappropriate/ Unexpected QC	Correlation	**.447****	.413**	.489**	.412**	.455**	.457**	.474**	.287*	.404**	.098
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.012	.000	.402
C20	Slow Client Response	Correlation	**.360****	.398**	.438**	.331**	.539**	.503**	.445**	.280*	.451**	.162
		Sig. (2-tailed)	.001	.000	.000	.004	.000	.000	.000	.014	.000	.162
C01	Inadequate/ Inaccurate Design Information	Correlation	**.402****	.473**	.312**	.420**	.486**	.355**	.418**	.273*	.417**	.224

		Sig. (2-tailed)	.000	.000	.006	.000	.000	.002	.000	.017	.000	.052
C06	Inappropriate Contract Form	Correlation	**.566****	.414**	.443**	.304**	.557**	.585**	.499**	.182	.455**	.115
		Sig. (2-tailed)	.000	.000	.000	.008	.000	.000	.000	.116	.000	.324

Appendix I. Spearman coefficients and p-value between the most frequented: Types of variations/claims and causes

	TYPE (Frequency)		T16	T23	T38	T45	T31	T34	T25	T07	T09	T10
CAUSE AVOIDABILITY	CORRELATION (Coefficients)		Delayed drawings or instructions	A variation or significant change to the quantities	Ambiguity in Documents	Acceleration of Works	An omission of work forming	Delayed payment	Shortage of personnel or goods	Rejection of defective plant and / or materials	Revised methods of working due to poor progress	Delay damages
C10	Inappropriate Contractor Selection	Correlation	.066	.231*	.283*	.064	.100	-.075	-.034	.141	.127	.114
		Sig. (2-tailed)	.570	.045	.013	.584	.390	.521	.772	.225	.273	.325
C13	Inappropriate Payment Method	Correlation	.096	.084	.268*	.334**	.405**	-.022	.208	.101	.133	.136
		Sig. (2-tailed)	.411	.473	.019	.003	.000	.852	.072	.385	.251	.243
C06	Inappropriate Contract Form	Correlation	**.229***	.318**	.294**	.142	.458**	.083	-.010	.082	.173	.286*
		Sig. (2-tailed)	.046	.005	.010	.221	.000	.478	.933	.479	.135	.012
C05	Inappropriate Contract Type	Correlation	**.333****	.170	.168	.157	.264*	.096	-.081	.046	.348**	.192
		Sig. (2-tailed)	.003	.142	.147	.175	.021	.412	.489	.695	.002	.097
C01	Inadequate/ Inaccurate Design	Correlation	-.067	.020	.149	.162	.109	.077	.024	.198	.262*	.173
		Sig. (2-tailed)	.566	.863	.198	.163	.348	.509	.834	.086	.022	.136
C24	Inadequate Site Investigation	Correlation	.055	.197	.250*	.012	.162	-.080	-.076	.214	.259*	.212
		Sig. (2-tailed)	.635	.088	.029	.920	.161	.494	.513	.064	.024	.066
C04	Unclear & Inadequate Specifications	Correlation	-.041	.027	.068	.035	-.025	.012	-.067	.117	.235*	.070
		Sig. (2-tailed)	.724	.814	.560	.765	.831	.915	.567	.313	.041	.546
C02	Inadequate/ Inaccurate Design Information	Correlation	.148	.175	.290*	.091	.181	.109	.032	.393**	.361**	.373**
		Sig. (2-tailed)	.202	.131	.011	.432	.117	.350	.782	.000	.001	.001
C08	Inadequate Contract Documentation	Correlation	.139	.162	.227*	.276*	.176	.170	.008	.211	.397**	.335**
		Sig. (2-tailed)	.230	.163	.048	.016	.129	.141	.945	.068	.000	.003
C07	Inadequate Contract Administration	Correlation	.055	-.163	.148	-.062	.201	.010	.022	.169	.094	-.032
		Sig. (2-tailed)	.639	.158	.203	.597	.082	.930	.852	.145	.421	.782
C09	Incomplete Tender Information	Correlation	.101	.216	.051	.192	.180	.022	.056	.164	.329**	.167
		Sig. (2-tailed)	.387	.060	.664	.096	.120	.851	.629	.156	.004	.150

** indicates the statistically highly positive correlation.

Appendix J. Spearman coefficient and p-value between the most impacted types of variations/claims and most avoid ability causes

	TYPE (IMPACT)		T39	T47	T16	T41	T27	T38	T33	T23	T26	T48
CAUSE AVOIDABILITY	CORRELATION		Loss of works caused Employer's Risks	Client's Breach of Contract	Delayed drawings or instructions	Force Majeure	Delays caused by authorities	Ambiguity in Documents	Changes in legislation	A variation or significant change to the quantities	Employer's delay or impediment	Inflation / Price Escalation
C10	Inappropriate Contractor Selection	Correlation Coefficient	.222	.307**	.305**	.244*	.308**	.185	.359**	.227*	.179	.294**
		Sig. (2-tailed)	.054	.007	.007	.034	.007	.109	.001	.048	.121	.010
C13	Inappropriate Payment Method	Correlation Coefficient	.143	.370**	.206	.240*	.271*	.360**	.226*	.205	.190	.042
		Sig. (2-tailed)	.216	.001	.074	.037	.018	.001	.050	.076	.099	.717
C06	Inappropriate Contract Form	Correlation Coefficient	**.301****	.354**	.330**	.237*	.510**	.520**	.434**	.186	.459**	.150

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		Sig. (2-tailed)	.008	.002	.004	.039	.000	.000	.000	.109	.000	.195
C05	Inappropriate Contract Type (Strategy)	Correlation	**.251***	.275*	.295**	.183	.388**	.298**	.352**	.145	.258*	.198
		Sig. (2-tailed)	.029	.016	.010	.113	.001	.009	.002	.212	.025	.087
C01	Inadequate/ Inaccurate Design Information	Correlation	.070	.295**	.055	.066	.073	.176	.299**	.132	.165	.088
		Sig. (2-tailed)	**.548**	.010	.635	.572	.533	.128	.009	.256	.153	.449
C24	Inadequate Site Investigation	Correlation	.164	.266*	.222	.184	.302**	.254*	.306**	.303**	.248*	.241*
		Sig. (2-tailed)	.156	.020	.054	.111	.008	.027	.007	.008	.030	.036
C04	Unclear & Inadequate Specifications	Correlation	.043	.166	.006	-.008	.073	.064	.160	.210	.063	.104
		Sig. (2-tailed)	**.712**	.151	.957	.949	.531	.580	.169	.069	.590	.369
C02	Inadequate/ Inaccurate Design Information	Correlation	.178	.183	.142	.325**	.381**	.229*	.415**	.145	.344**	.116
		Sig. (2-tailed)	.125	.115	.221	.004	.001	.046	.000	.212	.002	.318
C08	Inadequate Contract Documentation	Correlation	**.219**	.310**	.227*	.191	.434**	.278*	.483**	.193	.305**	.342**
		Sig. (2-tailed)	.058	.006	.048	.099	.000	.015	.000	.094	.007	.003
C07	Inadequate Contract Administration	Correlation	.016	.190	.086	.048	.152	.127	.277*	.071	.171	.183
		Sig. (2-tailed)	**.893**	.099	.458	.679	.190	.276	.015	.540	.140	.113
C09	Incomplete Tender Information	Correlation	.097	.095	.062	.176	.116	-.033	.164	.214	.135	.115
		Sig. (2-tailed)	**.403**	.414	.592	.128	.317	.779	.157	.063	.247	.322

** indicates the statistically highly positive correlation.

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