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The Causes Influencing the Occurrence of Variation Orders in the Construction of Buildings

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ABSTRACT

In the construction of buildings usually, problems occur because of the causes of change orders. The main causer of change orders is the owners, consultants, and contractors. These changes lead to conflicts among them which result in influencing building projects. Therefore, it is necessary to analyze the causes of change orders to reduce them and facilitate management. This paper determines the most critical factors that cause change orders from a different point of view, a consulting owner and a contractor, and a study of the reality of the management of change orders when constructing public buildings. The method employed in this research is a field survey using interviews with experts working in the construction of public buildings. Furthermore, the questionnaire was distributed manually and electronically.

In conclusion, it would appear that the causes of change orders have been hierarchically according to the viewpoint of the owner, contractor, and consultant. The analysis leads to the following conclusions: Agreement of viewpoints owners, contractors, and consultants on the critical causes of variation orders were: (the difficult financial situation - change material specifications to benefit the project - technical necessity - the nature of the site). Moreover, the point of view (owners and contractors) on the essential factors that cause change orders were: (preparing a bill of quantities is inaccurate - weak consultant guess). In contrast, the consultant's point of view differs, as he considers these causes ineffective. It can be interpreted that the consultant sees these factors as insignificant because of his duty to implement the bill of quantities and designs. This research paper concludes that a complex causal relationship exists between the causes of change orders. The relative importance index (RII) for variation order causes varies among different groups' viewpoints (owners, contractors, and consultants).

Keywords: Variation orders, Cause change orders, Field survey, Cause (variation orders) breakdown structure (CBS).

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الأسباب المؤثرة في حدوث أوامر التغيير في تشييد المباني

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الخلاصة

تحدث المشاكل عادة في تشييد المباني بسبب أوامر التغيير. المسبب الرئيس لاوامر التغيير.هم المالكون والاستشاريون والمقاولون. تؤدي هذه التغييرات إلى نزاعات فيما بينها مما يؤدي إلى التأثير على مشاريع التشييد. لذلك، من الضروري تحليل أسباب اوامر التغيير لتقليله وتسهيل عملية ادارتها. تحدد هذه الورقة أهم اسباب التي تسبب أوامر التغيير من وجهة نظر مختلفة، مالك واستشاري ومقاول. بالإضافة إلى دراسة واقع إدارة أوامر التغيير عند تشييد المباني العامة. الأساليب المتبعة في هذه الورقة البحثية المسح الميداني من خلال إجراء مقابلات مع الخبراء العاملين في تشييد المباني العامة، كما تم توزيع الاستبيان يدوياً وإلكترونياً. في الختام، اتضح اتفاق اراء (الملاك والاستشاريون والمقاولون) على العوامل المهمة التي تسبب أوامر التغيير و كانت: (الوضع المالي الصعب – تغيير المواصفات الانشائية لصالح المشروع – الضرورة الفنية – طبيعة الموقع). علاوة على ذلك ، فإن وجهة نظر (المالك والمقاولين) حول العوامل الأساسية التي تسبب أوامر التغيير كانت: (ضعف في إعداد جداول الكميات – ضعف تخمين الاستشاري). في المقابل ، تختلف وجهة نظر الاستشاري. حيث يعتبر هذه الأسباب ليست مؤثرة. يمكن تفسير ذلك بسبب واجبه في تنفيذ جدول الكميات و التصاميم. بينت هذه الورقة البحثية إلى وجود علاقة سببية معقدة بين أسباب أوامر التغيير. واختلاف مؤشر الأهمية النسبية لاسباب أوامر التغيير بين الأطراف المختلفة (المالك والاستشاري والمقاول) حسب وجهات نظرهم.

الكلمات الرئيسية: أوامر التغيير، سبب أوامر التغيير، المسح الميداني، هيكل تجزئة أسباب أوامر التغيير.

1. INTRODUCTION

Change orders result from the owner's confirmed edits to terms and conditions described in a project contract (**Bolin**, **2017**). Because of the numerous change or variation orders in construction projects, there is necessary to examine which causes (**Maluleke, et al., 2019**). The construction function is linked with modifications because of its complicated nature, leading to variation orders. (**Muhammad et al.**, **2015**). Change or variation orders are two terms that are usually used interchangeably in practice (**Jarkas and Mubarak**, **2016**). Some definitions specify change orders as variation orders (**Alshdiefat and Aziz**, **2018**). One of the significant situations facing the construction project is a matter of variation orders during the construction phase (**Mohammad, et al., 2017**). The most common reason for conflicts and failures of projects is the change orders (**Khoso et al.**, **2019**). They are complex to manage without understanding the actual causes of change.

Nonetheless, they can be decreased. Variation orders (change orders) are often the causality of project delays and overreaching the project budget. (**Czemplik**, **2017**). The variation became part of construction projects, and it is irregular that any project is carried out according to its intent, which creates challenges for the project parties (**Ahmed et al.**, **2016**). Change orders are a primary cause of construction claims (**Jarkas and Mubarak**, **2016**), contributing to time-consuming and costly negotiations between owner and contractor. Therefore, it is essential to manage change orders properly to avoid or lessen their negative influences (**Handayani, et al., 2019**). Variation orders are issued to adjust the scope of work because differences during the construction of projects

are unavoidable (**Endris Yadeta**, **2016**). Variation orders are " allowing changes or modification to be incorporated into an earlier agreement made by both parties either in terms of quantity or the nature of a task to be implemented, where these variations nevertheless occur after the award of the contract or after work might have initiated at the sites " (**Sani and Gidado**, **2014**). If there is no change in a project, its total original bid is what the contractor will gain at the ending project. Nonetheless, this is seldom the matter, and final payments made to the contractor are almost never similar to the earliest bid (**Shafaat et al.**, **2016**). The potential impacts related to variation orders were delays in the completion schedule, an increase in cost, poor professional relationships, and disputes between parties (**Ghenbasha et al.**, **2018**) .After the owner's approval, the engineer could, at any time, before the issue of the initial work delivery request to conduct variation in the works, either via instructions or by request to the contractor, who must submit a suggestion for consideration. The contractor ought to implement the variation order unless he offers notice to the engineer, supporting the details. The contractor informs him of his inability to obtain the implementation requirements required to implement the change works on time, or this change significantly affects the progress of the work. When the engineer receives such notices, the engineer should cancel, prove or amend his instructions (The Government Contracts Implementation Instructions (2), 2014; Standard Bid Documents, 2016). In this research paper, the most critical root causes of change orders will be identified, and investigate a statistically significant relationship among the answers of the owner, contractor, and consultant.

2. PREVIOUS STUDIES

Various researches have been established to determine and prioritize the variation order s causes. A questionnaire was organized and distributed to different respondents to acquire information concerning the causes and influences of variation orders, and the gathered information was analyzed using (RII) method **(Onkar, 2015)**. **(Sani and Gidado 2014)** conducted a preliminary survey on the identified causes in literature, and the respondents were asked to tick the most common occurrence within the study area generally. That study reported that change in specification (MS = 23.28), change in design (MS = 19.98), and change in government regulation (MS = 19.44) are the most significant factors causing variation order in the study area. It concluded that consultant and client-related changes with (MS =117.90 and 115.62) were the main origins of variation orders. **(Staiti and Othman, 2015)** identified the major causes of variation in construction projects in the West Bank and the impacts of variation orders on the Palestinian construction project and assessed the existing traditional ways of variation orders management at the companies of construction in the West Bank. Generally, the study showed that variation orders appeared more frequently in adding new works: increasing work quantities by adding new activities. Also, results showed that the main source of changes is the owner. **(Khan, 2016)** suggested a framework for change orders management in the construction project by examining the various causes of change orders and their influences on cost, duration, and quality. Also shown, three causes of change orders are "Change in specifications by the owner", "Change of plans or scope by the owner", and "Poor project planning by the contractor". **(M. Fadl and H. Nassar, 2017)**) Conducted a model by determining the causes of variation orders in construction projects in Egypt and investigated the influence of variation orders on the construction project**. (Alhilli, et al., 2021)** investigated the causes of change orders, as illustrated in Table 6, Table 7, Table 8, Table 9. It is shown a hierarchical structure comparable to the work breakdown structure is called cause (variation orders) breakdown structure. (CBS). It is defined as a tool describing the hierarchical structure of variation orders causes, and it is represented from 1st to 3rd levels (C, C1, C2)..Ali (2022) specified the causes of change orders in projects implemented between 2007-and

2014 in the Erbil governorate **(Ali, 2021)**. **(Mohammed, 2016),(Wali and Saber, 2019),(Ismaeel and Naji, 2021), (Ahmed et al., 2017), (Alaryan et al., 2014), (Enshassi, et al., 2010), (Memon, et al., 2014),(Khanzadi, et al., 2018)** classified the causes for change orders according to the causative, (owner, consultant and contractor, other). and their classification doesn't include (designs - contract - project management - administrative aspects - materials - equipment - site conditions - external factors - safety aspects). So, there is a research gap, and previous research showed the causes of variation orders independent. On the other hand **(Khanzadi, et al., 2018), (Alhilli, et al., 2021)** confirmed the interrelationships among the causes of change orders. We argue that previous literature suffers from certain weaknesses in determining the (RII) for the essential root causes of variation orders. Because previous studies assumed that change orders were independent. In spite of some previous studies assuming that the causes of variation orders are interrelated, which could not calculate (RII) of the root causes of variation orders from the point of view of the owner, contractor and consultant.

3. PROBLEM STATEMENT AND OBJECTIVES

Because of the adverse impacts of variation orders represented in the deviation of cost, duration, quality, and project performance, it is necessary to analyze the critical causes of the variation orders to reduce them. In general, the problem can be addressed by calculating the (RII) of the variation orders causes according to causative ((owner-contractor- consultant - designs - contract - project management - administrative aspects - materials - equipment - site conditions - external factors - safety aspects)). The management of change orders during the construction of public buildings was studied using field investigation. The aim here is to investigate a statistically significant relationship between the owner, contractor, and consultant answers.

4. METHODOLOGY

The research methodology is illustrated in **Fig. 1**. The primary pursuit of this paper is to specify the critical causes for the occurrence of change orders in construction projects. While to achieve these objectives, this study was divided into five stages. In the first stage, the qualitative approach was represented by a field survey (interviews) with experts specializing in the construction of public buildings. In the second stage, the quantitative method was described by (questionnaires) and consisted of questionnaire development. In the third stage, The final form of the questionnaire was distributed manually and electronically and collected the data. In the fourth stage, descriptive statistics were conducted using the (RII) after the data were collected. In the fifth stage, inductive statistics were performed using a statistical test one-way analysis of variance (ANOVA). The post_test Tukey's test was conducted to determine different groups' viewpoints (owners, contractors, and consultants). These stages are described in detail as follows.

4.1 Interviews

Interviews were executed with experts and specialists in constructing the school, industrial, educational, and health buildings. The experts were selected according to their jobs, representing the owner, consultants, and contractors. The purpose is to determine the most critical causes for change orders depending on the type of contract and delivery system.

4.2 Questionnaire development

First, a questionnaire was prepared based on literature studies and interviews. The questionnaire included general information and managing change orders. The general information contained data

related to the governmental institution, employment, qualification, specialization, practical experience, project type, contract type, and the delivery system.

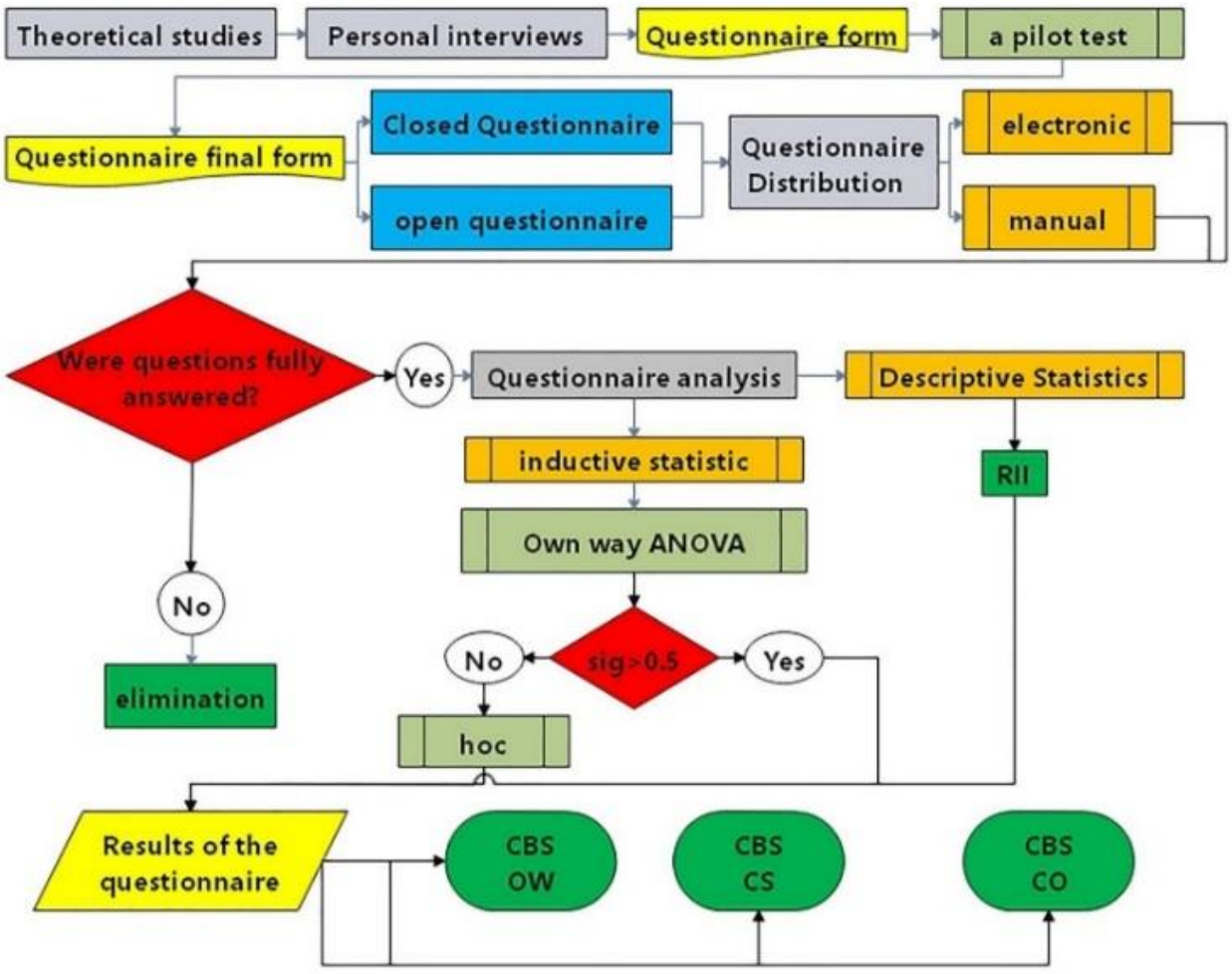

Figure 1. Research Methodology

Managing change orders included general information, the factors causing change orders, and general questions. Secondly, before conducting the closed questionnaire on the target respondents, a trial and validation of the questions were conducted. SPSS V. 24 program was used for statistical analysis in this research paper.

4.2.1 Reliability and internal consistency

A pilot test (a short-scale test conducted in preparation for the main study, where a sample size of 10–20% of the sample required for the actual field investigation) was conducted to establish the questionnaire reliability (**Jarkas and Mubarak**, **2016**). The questionnaire, consequently, was assigned to 25 respondents (nearly 19% of the sample size). Cronbach's alpha equation was used to ensure the consistency of the study tool on the pilot sample size. It was excluded from the total sample. **Table 1** shows the reliability coefficient.

Table 1. The reliability coefficient Cronbach's alpha

Factors causing change orders		
Causes	Sub causes	Consistency
C1	19	0.89
C2	10	0.916
C3	11	0.845
C4	13	0.873
C5	9	0.845
C6	11	0.934
C7	9	0.768
C8	5	0.852
C9	9	0.793
C10	2	0.748
C11	5	0.738
C12	10	0.755
total	113	0.964

The questionnaire enjoys a high degree of reliability. According to the Nani scale (0.7) (Nunnally, et al., 1994), as a minimum, it can be trusted in the field survey. It is clear from Table 2 that the overall stability coefficient of the questionnaire axes is high as it reached (0.964) while the stability of the axis ranges between (0.738-0.934).

Table 2. The internal consistency validity of the questionnaire

Factors causing change orders				
Causes	Sub causes	Correlation coefficient		Significance value
		MAX.	MIN.	
C1	19	0,793	0,282	0,001
C2	10	0,885	0,680	0,001
C3	11	0,782	0,412	0,001
C4	13	0,805	0,325	0,001
C5	9	0,8	0,411	0,001
C6	11	0,89	0,618	0,001
C7	9	0,746	0,275	0,001
C8	5	0,9	0,677	0,001
C9	9	079	0,492	0,001
C10	2	0,914	0,877	0,001
C11	5	0,797	0,609	0,001
C12	10	0,228	0,763	0,001

The internal consistency validity of the questionnaire was checked by calculating the Pearson correlation coefficient, as shown in **Table 2**. It was concluded from the results of the internal consistency stability that the questionnaire has a high degree of stability and validity of internal

consistency. However, the final form of the questionnaire was distributed manually and electronically.

4.2.2 Data Collection

The minimum questionnaire sample size was determined based on Eq. (1) (**Thompson**, **2012**). Applying Eq. (2) to select the minimum sample size according to the work jobs is possible. **Table 3** shows the minimum sample size required.

Table 3. The minimum questionnaire sample size

	N	Minimum ($\boldsymbol{ni}$)	Selected sample size
Ministry of Higher Education			
The University of Baghdad and University of Kufa	70	48	50
Ministry of Health			
Baghdad Health Directorate - Al-Karkh	24	16	16
Ministry of Education			
The General Directorate of Education in Baghdad, Al-Karkh 3rd	40	27	27
Ministry of Industry			
Engineering Center Department	25	17	20
Industrial Cities Department	24	16	20
Total	183	125	133

$$\boldsymbol{n} = \frac{\boldsymbol{N}\times\boldsymbol{p}(\boldsymbol{1}-\boldsymbol{p})}{[(\boldsymbol{N}-\boldsymbol{1})\times(\boldsymbol{d^2}\div\boldsymbol{z^2})+\boldsymbol{p}(\boldsymbol{1}-\boldsymbol{p})]} \quad (1)$$

Where $\boldsymbol{N}$ is the population size, $\boldsymbol{n}$ is a sample size, $\boldsymbol{z}$: The standard score corresponding to the significance level is 0.95 and is equal to 1.96, $\boldsymbol{d}$: Error rate = 0.05, $\boldsymbol{p}$: response distribution. When applied in Eq. (1), n must be taken with a sample size of at least 125.

$$\boldsymbol{ni} = \frac{\boldsymbol{Ni}}{\sum_i^j \boldsymbol{N}} \times \boldsymbol{n} \quad (2)$$

Where $\boldsymbol{ni}$: the minimum sample size required, $\boldsymbol{Ni}$: The size of the population in the institution, $\boldsymbol{N}$: The total size of the population in all institutions, $\boldsymbol{n} = 125$

5. RESULTS

Data analysis employs two primary statistical methods: descriptive statistics, which summarise data using indices such as mean and median, and inferential statistics, which draws conclusions from data using statistical tests.

5.1 Descriptive Statistics

Fig. 2 shows respondents' information, and **Table 4** illustrates the type of building projects, contracts, and delivery systems.

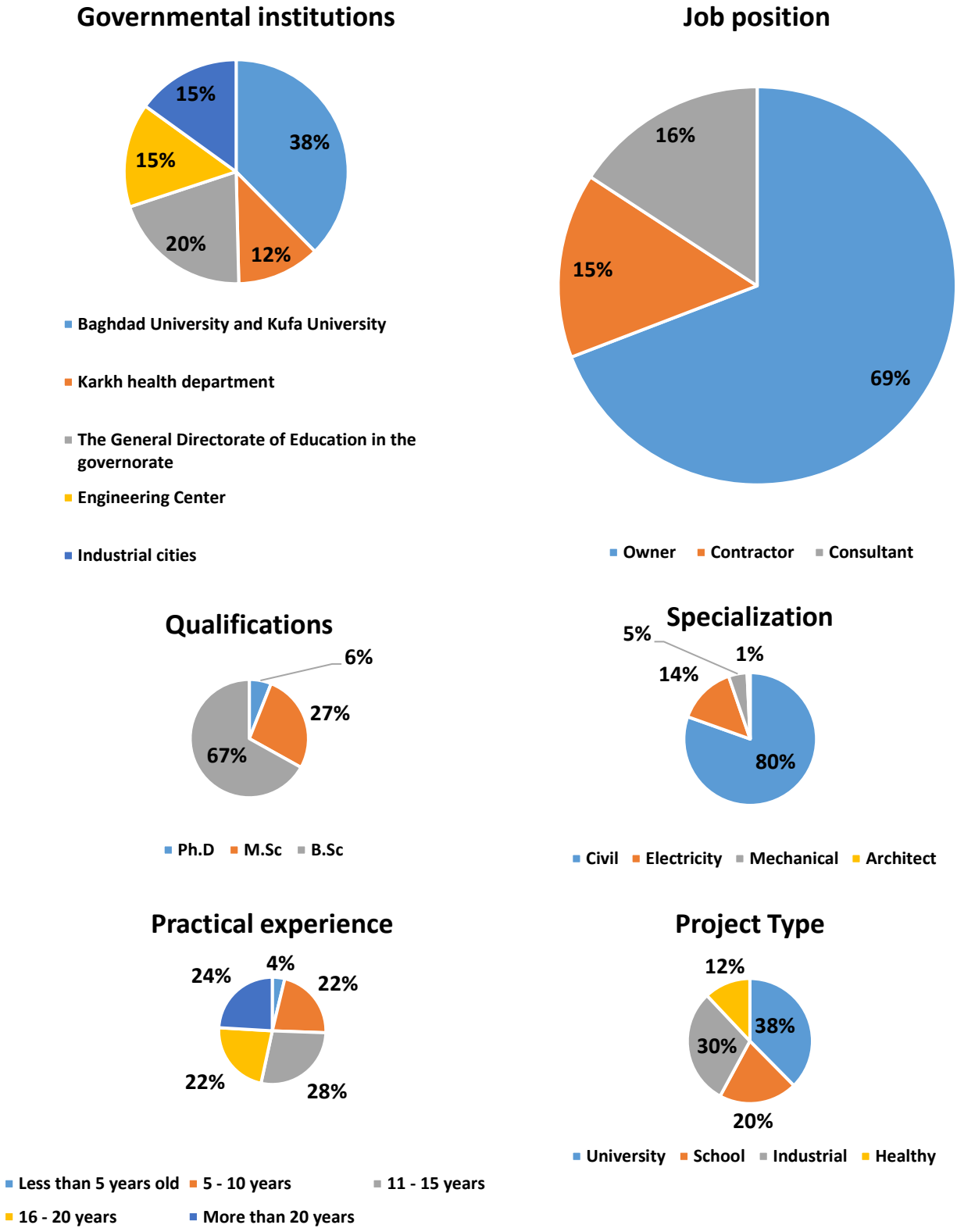

Figure 1. The information of respondents

Table 4 shows that the contract type in public building projects is the bill of quantities, whereas the method of carrying out a general contractor and design and build.

Table 4. The type of contract and delivery systems

No.	Type	Responses	Percent
Contract			
1	Lump Sum	64	35.8%
2	Bill of Quantities	113	63.1%
3	Unit Price	2	1.1%
Delivery systems			
1	General contractor	101	59.4%
2	Design and Build	69	40.6%

(RII) was used to analyze the collected data for each question, with a five-point Likert scale quantified by Eq. (3), Eq. (4) **(Jarkas and Mubarak, 2016)**.

$$RII = (\sum \frac{W}{AN}) \times 100 \quad (3)$$

$$RII = \frac{5(m5)+4(m4)+3(m3)+2(m2)+(m1)}{5\times N} \quad (4)$$

Where W: The respondents' weight given to each item ranges from (1-to 5). For example, one is the least implying (Never), and five is the highest implying (Always).
A: The highest weight (5 on a five-point Likert scale)
N: The total number of respondents.
(m1; m2; m3; m4; and m5) : The number of respondents selected (Never – Rarely - Sometimes - Often - Always) respectively. **Table 5** illustrates (RII) general information about change orders.

Table 5. Illustrates (RII) general information

N	General information about change orders	Mean	Std. Deviation	(RII)
Change order type				
1	Increase quantities	4.01	0.88	0.802
2	Create	3.65	0.87	0.73
3	Reduce quantities	3.39	1.09	0.678
4	Delete	3.35	1.04	0.67
5	Modify a specification (delete and create)	3.17	0.83	0.634
Change order work				
1	Civil	4.22	0.92	0.84
2	Electrical	3.74	0.8	0.75
3	Plumping	3.17	1.02	0.63
4	Mechanical	3	0.88	0.6
5	Architectural	2.71	1.04	0.54
The size and number of change orders increases				
1	With the size and complexity of the project	4.08	0.81	0.82
2	With an increase in the bid amount	3.18	1.22	0.64

Table 6. Illustrates (RII) general information (continue)

The beneficiary of the change orders				
1	The contractor will benefit more from change orders	3.49	1.03	0.7
2	The owner will benefit more from change orders	3.31	1.21	0.66
3	None of the three parties will benefit from change orders	2.65	1.1	0.53
4	The consultant will benefit more from change orders	2.53	0.98	0.51

Fig. 3 showed general questions about the reality of managing change orders in public institutions. **Table 6, Table 7, Table 8, and Table 9** illustrated (RII) the factors causing variation orders according to the views of the owner, contractor, consultant, and overall. (T)

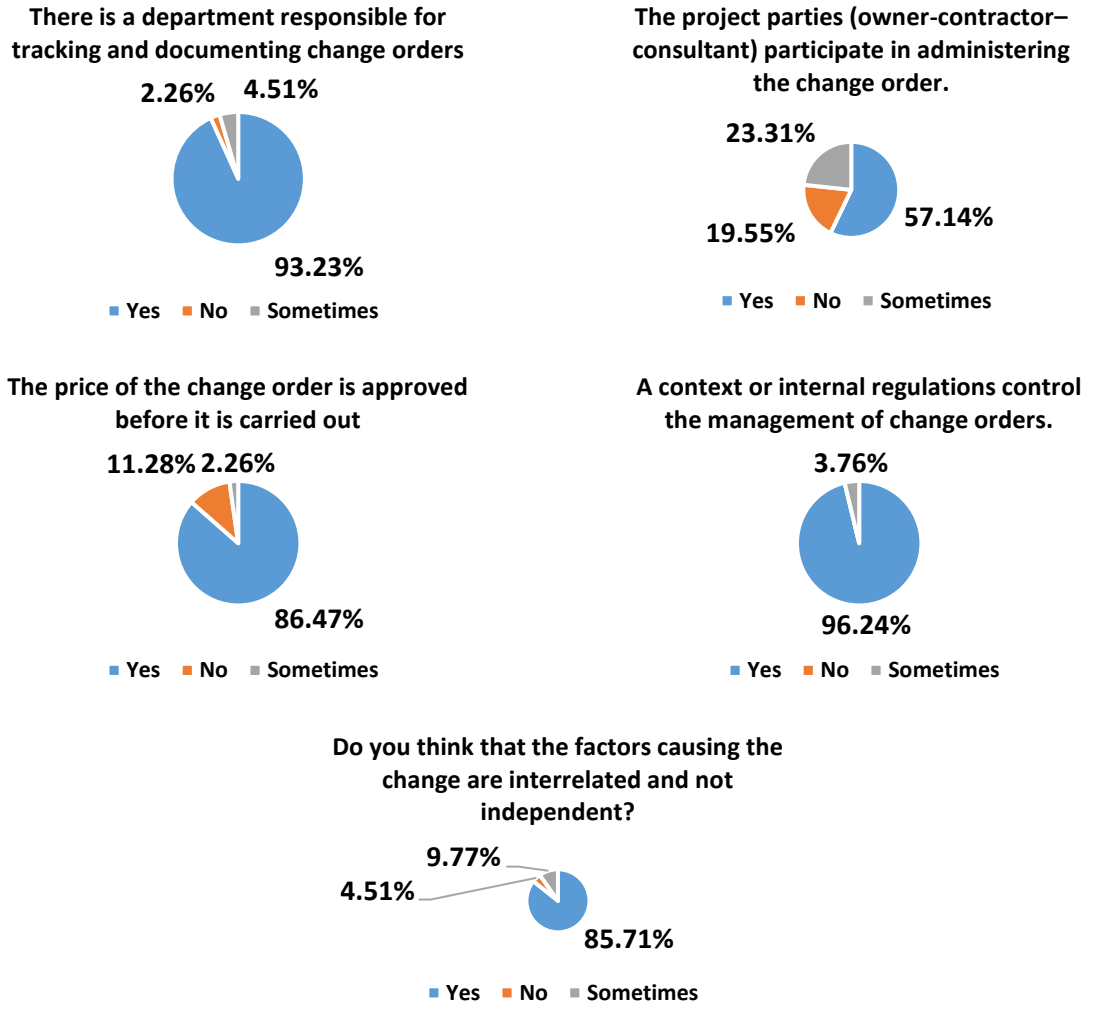

Figure 2. General questions about the reality of managing change orders

Table 6. The (RII) of the factors causing variation orders.

CBS Code	CBS Name	(OW) Code	RII	(CS) Code	RII	(CO) Code	RII	(T) Code	RII
C.1	owner	OW.1		CS.1		CO.1		T.1	
C.1.1	Schedule change	OW.1.1	0.63	CS.1.1	0.63	CO.1.1	0.74	T.1.1	0.65
C.1.2	Scope change	OW.1.2	0.60		0.59	CO.1.2	0.63	T.1.2	0.61
C.1.3	Change in the Action Plan	OW.1.3	0.61		0.53	CO.1.3	0.60		0.59
C.1.4	Decision making is slow and complicated	OW.1.4	0.62		0.52		0.57		0.59
C.1.5	The delay in the payment of the contracting parties	OW.1.5	0.68	CS.1.2	0.74	CO.1.4	0.77	T.1.3	0.70
C.1.6	Difficult financial situation	OW.1.6	0.73	CS.1.3	0.66	CO.1.5	0.70	T.1.4	0.71
C.1.7	The character of the owner is strict and inflexible		0.58		0.59		0.57		0.58
C.1.8	The goals of the project are incomplete	OW.1.7	0.65		0.58	CO.1.6	0.63	T.1.5	0.64
C.1.9	Owner requirements incomplete	OW.1.8	0.60	CS.1.4	0.63	CO.1.7	0.64	T.1.6	0.61
C.1.10	Weakness in reviewing project documentation	OW.1.9	0.66	CS.1.5	0.72	CO.1.8	0.68	T.1.7	0.68
C.1.11	Owner requirements unclear	OW.1.10	0.66	CS.1.6	0.61	CO.1.9	0.66	T.1.8	0.65
C.1.12	Job change in project structure		0.53		0.54		0.52		0.53
C.1.13	Weakness in project management	OW.1.11	0.60		0.57	CO.1.10	0.63	T.1.9	0.60
C.1.14	Lack of owner experience		0.58		0.54	CO.1.11	0.73	T.1.10	0.60
C.1.15	Not to hand over the site right time for the contractor		0.55		0.54	CO.1.12	0.64		0.57
C.1.16	Change in the sequence of implementation of the most heavily		0.56	CS.1.7	0.64	CO.1.13	0.63		0.58
C.1.17	Desire to start early in the project		0.52		0.55		0.56		0.53
C.1.18	Determine the time of activities is not suitable		0.57		0.50		0.56		0.56
C.1.19	Change the decision-making authority frequently	OW.1.12	0.62	CS.1.8	0.65		0.57	T.1.11	0.61
C.2	Consultant	OW.2		CS.2		CO.2		T.2	
C.2.1	Lack of coordination between different specialization designers	OW.2.1	0.68		0.50	CO.2.1	0.63	T.2.1	0.65
C.2.2	Lack of consultant experience	OW.2.2	0.68		0.50	CO.2.2	0.65	T.2.2	0.65
C.2.3	The consultant was late in approving		0.58		0.57	CO.2.3	0.73	T.2.3	0.60
C.2.4	Delayed in responding to problems	OW.2.3	0.68	CS.2.1	0.69	CO.2.4	0.71	T.2.4	0.69
C.2.5	Inflexible consultant personality	OW.2.4	0.69		0.53	CO.2.5	0.62	T.2.5	0.65
C.2.6	Weakness of supervision as a representative of the owner		0.58		0.40	CO.2.6	0.66		0.57
C.2.7	Lack of experience and knowledge of the presence of materials in the market	OW.2.5	0.67		0.50	CO.2.7	0.72	T.2.6	0.65
C.2.8	Weakness in preparing bill of quantities	OW.2.6	0.80		0.50	CO.2.8	0.67	T.2.7	0.73
C.2.9	Weak consultant guess	OW.2.7	0.75		0.49	CO.2.9	0.63	T.2.8	0.69
C.2.10	Poor identification of the logical relationship between the activities of the bill of quantities	OW.2.8	0.71		0.50		0.51	T.2.9	0.65

Table 7. The (RII) of the factors causing variation orders.

CBS Code	CBS Name	(OW) Code	RII	(CS) Code	RII	(CO) Code	RII	(T) Code	RII
C.3	Designs	OW.3		CS.3		CO.3		T.3	
C.3.1	Lack of clarity designs and technical specifications	OW.3.1	0.73		0.55	CO.3.1	0.68	T.3.1	0.69
C.3.2	Errors and omissions in designs	OW.3.2	0.73		0.53	CO.3.2	0.75	T.3.2	0.71
C.3.3	The level of complexity of designs	OW.3.3	0.61		0.58	CO.3.3	0.68	T.3.3	0.62
C.3.4	Insufficient design details to work	OW.3.4	0.63	CS.3.1	0.68	CO.3.4	0.63	T.3.4	0.64
C.3.5	Design inconsistency with regulations		0.54		0.44		0.58		0.53
C.3.6	Designs not meeting the owner's requirements	OW.3.5	0.70	CS.3.2	0.61	CO.3.5	0.68	T.3.5	0.68
C.3.7	The workshop layout is insufficient	OW.3.6	0.67		0.52		0.54	T.3.6	0.63
C.3.8	Errors and omissions in calculating quantities	OW.3.7	0.77		0.51	CO.3.6	0.62	T.3.7	0.71
C.3.9	Value engineering		0.59		0.49		0.50		0.56
C.3.10	Delay in reviewing designs (ambiguity in designs)	OW.3.8	0.72		0.50	CO.3.7	0.65	T.3.8	0.67
C.3.11	Citation specification is not suitable for the project		0.55		0.55		0.54		0.54
C.4	contractor	OW.4		CS.4		CO.4		T.4	
C.4.1	Weak contractor management and supervision	OW.4.1	0.71	CS.4.1	0.60		0.59	T.4.1	0.67
C.4.2	Poor contractor planning and scheduling	OW.4.2	0.70	CS.4.2	0.60		0.54	T.4.2	0.66
C.4.3	Bad contractor financial position	OW.4.3	0.62	CS.4.3	0.60	CO.4.1	0.70	T.4.3	0.63
C.4.4	Weakness of the contractor's work team	OW.4.4	0.70	CS.4.4	0.64	CO.4.1	0.68	T.4.4	0.69
C.4.5	Secondary contractors are ineffective	OW.4.5	0.70	CS.4.5	0.61	CO.4.1	0.74	T.4.5	0.69
C.4.6	Desire to make profits	OW.4.6	0.73	CS.4.6	0.69	CO.4.1	0.72	T.4.6	0.72
C.4.7	Poor communication between the project parties and the contractor	OW.4.7	0.67		0.58	CO.4.1	0.65	T.4.7	0.65
C.4.8	Delay in paying the dues of secondary contractors, suppliers and manpower		0.52		0.57		0.47		0.52
C.4.9	Delayed supply of resources		0.59		0.50	CO.4.1	0.60		0.58
C.4.10	Poor supply of resources and equipment to the site	OW.4.8	0.67	CS.4.7	0.65	CO.4.1	0.68	T.4.8	0.67
C.4.11	The complexity of designs by the contractor		0.57		0.47	CO.4.1	0.60		0.55
C.4.12	Failure to coordinate with the employer supervising authority	OW.4.9	0.67	CS.4.8	0.60	CO.4.1	0.63	T.4.9	0.65
C.4.13	Lack of productivity of the contractor's work team		0.59		0.54		0.57		0.58
C.5	project management	OW.5		CS.5		CO.5		T.5	
C.5.1	Lack of coordination between the parties	OW.5.1	0.68	CS.5.1	0.60	CO.5.1	0.72	T.5.1	0.68
C.5.2	Poor communication	OW.5.2	0.63		0.59	CO.5.2	0.68	T.5.2	0.63
C.5.3	Weak data available	OW.5.3	0.61	CS.5.2	0.60	CO.5.3	0.64	T.5.3	0.61
C.5.4	The work progress schedule is unclear	OW.5.4	0.61	CS.5.3	0.60	CO.5.4	0.60	T.5.4	0.61
C.5.5	A change in project regulations		0.54		0.55		0.55		0.54

Table 8. The (RII) of the factors causing variation orders.

CBS Code	CBS Name	(OW) Code	RII	(CS) Code	RII	(CO) Code	RII	(T) Code	RII
C.5.6	Poor risk management		0.50		0.45		0.56		0.50
C.5.7	Occupational safety procedures		0.55		0.50		0.59		0.55
C.5.8	Weak field experience of the Resident Engineer	OW.5.5	0.65	CS.5.4	0.69		0.58	T.5.5	0.65
C.5.9	Adhere to the routine procedures for obtaining approvals for the conduct of work	OW.5.6	0.70	CS.5.5	0.64	CO.5.5	0.61	T.5.6	0.67
C.6	Contract	OW.6		CS.6		CO.6		T.6	
C.6.1	Conflict in the contract documents	OW.6.1	0.68	CS.6.1	0.60	CO.6.1	0.67	T.6.1	0.67
C.6.2	Contract documents are unclear	OW.6.2	0.65		0.58	CO.6.2	0.63	T.6.2	0.64
C.6.3	The scope of work is not clear in the contract	OW.6.3	0.60		0.59	CO.6.3	0.67	T.6.3	0.61
C.6.4	Lack of contract documents	OW.6.4	0.65		0.55	CO.6.4	0.61	T.6.4	0.63
C.6.5	Poor contract preparation	OW.6.5	0.65	CS.6.2	0.60	CO.6.5	0.74	T.6.5	0.65
C.6.6	Inaccurate review of the contract	OW.6.6	0.62	CS.6.3	0.65	CO.6.6	0.70	T.6.6	0.63
C.6.7	The contract does not include all aspects of the project	OW.6.7	0.63		0.54	CO.6.7	0.74	T.6.7	0.63
C.6.8	Contract is not appropriate, such as this type of work	OW.6.8	0.64		0.59	CO.6.8	0.60	T.6.8	0.62
C.6.9	Terms of the contract contain clauses that are unclear	OW.6.9	0.62		0.59	CO.6.9	0.65	T.6.9	0.62
C.6.10	Corruption and suspicions in concluding contracts		0.53		0.54		0.56		0.53
C.6.11	Conducting the contract before completion of the contract documents	OW.6.10	0.63		0.58	CO.6.10	0.67	T.6.10	0.63
C.7	Materials	OW.7		CS.7		CO.7		T.7	
C.7.1	Unavailability of the required materials	OW.7.1	0.72		0.55	CO.7.1	0.65	T.7.1	0.68
C.7.2	Material failure in laboratory testing	OW.7.2	0.69	CS.7.1	0.61	CO.7.2	0.66	T.7.2	0.67
C.7.3	Delay in arrival of materials		0.57	CS.7.2	0.65		0.58		0.58
C.7.4	Change material specifications to benefit the project	OW.7.3	0.76	CS.7.3	0.66	CO.7.3	0.73	T.7.3	0.74
C.7.5	Change materials to achieve the same specifications and lower prices	OW.7.4	0.67		0.59	CO.7.4	0.65	T.7.4	0.65
C.7.6	Technical necessity	OW.7.5	0.74	CS.7.4	0.70	CO.7.5	0.67	T.7.5	0.73
C.7.7	Constructive necessity	OW.7.6	0.70	CS.7.5	0.68	CO.7.6	0.73	T.7.6	0.70
C.7.8	Poor transportation of materials in the project		0.51		0.55		0.58		0.53
C.7.9	Poor management of materials on site		0.54		0.56		0.56		0.55
C.8	Equipment	OW.8						T.8	
C.8.1	Insufficient equipment and tools		0.57		0.46		0.52		0.55
C.8.2	Use Obsolete Equipment and tools		0.58		0.50		0.47		0.55
C.8.3	Failure of the equipment to perform its work	OW.8.1	0.63		0.54		0.58	T.8.1	0.61
C.8.4	Poor performance of the equipment		0.59		0.54		0.53		0.57
C.8.5	Equipment malfunction when performing work		0.56		0.46		0.57		0.54
C.9	Administrative aspects	OW.9		CS.8		CO.8		T.9	

Table 9. The (RII) of the factors causing variation orders

CBS Code	CBS Name	(OW) Code	RII	(CS) Code	RII	(CO) Code	RII	(T) Code	RII
C.9.1	The lack of understanding between the project parties	OW.9.1	0.66	CS.8.1	0.74	CO.8.1	0.70	T.9.1	0.68
C.9.2	Failure to provide the revised designs with the specified time	OW.9.2	0.65	CS.8.2	0.73	CO.8.2	0.71	T.9.2	0.67
C.9.3	Poor communication between workers and management		0.54		0.59		0.58		0.55
C.9.4	Poor management	OW.9.3	0.67	CS.8.3	0.60	CO.8.3	0.63	T.9.3	0.65
C.9.5	Weakness in decision-making	OW.9.4	0.63	CS.8.4	0.65	CO.8.4	0.60	T.9.4	0.63
C.9.6	Municipal regulations and urban planning		0.50		0.56		0.54		0.52
C.9.7	Review the insurance regulations and the environmental protection		0.49		0.56		0.47		0.50
C.9.8	Fire fighting regulations and waste management regulations		0.46		0.54		0.50		0.48
C.9.9	Regulations for Archeology, roads and electricity		0.47		0.57		0.49		0.49
C.10	Safety aspects								
C.10.1	Safety procedures and policies not sufficient on-site		0.47		0.47		0.54		0.48
C.10.2	Site Safety Considerations		0.55		0.53		0.53		0.54
C.11	Site conditions	OW.10		CS.9		CO.9		T.10	
C.11.1	The nature of the site	OW.10.1	0.75	CS.9.1	0.70	CO.9.1	0.66	T.10.1	0.73
C.11.2	Transgressors	OW.10.2	0.72	CS.9.2	0.63	CO.9.2	0.68	T.10.2	0.70
C.11.3	the site situation	OW.10.3	0.71	CS.9.3	0.67	CO.9.3	0.65	T.10.3	0.69
C.11.4	Uncertainty problems of the land site	OW.10.4	0.65	CS.9.4	0.70	CO.9.4	0.66	T.10.4	0.66
C.11.5	Available work space		0.59		0.54		0.56		0.58
C.12	External factors	OW.11		CS.10		CO.10		T.11	
C.12.1	Environmental conditions		0.59		0.47		0.56		0.56
C.12.2	Economic conditions	OW.11.1	0.65		0.56		0.57	T.11.1	0.62
C.12.3	Political legislation		0.58		0.47		0.55		0.56
C.12.4	Third-party actions		0.59	CS.10.1	0.60		0.53		0.58
C.12.5	Force Majeure	OW.11.2	0.66	CS.10.2	0.70	CO.10.1	0.69	T.11.2	0.67
C.12.6	Emergency conditions	OW.11.3	0.71	CS.10.3	0.70	CO.10.2	0.70	T.11.3	0.71
C.12.7	Accidents	OW.11.4	0.61		0.46		0.57		0.58
C.12.8	Damage to the interests of people outside of the parties to the project		0.55		0.45		0.57		0.54
C.12.9	Political conditions		0.56		0.49		0.59		0.55
C.12.10	Cultural conditions		0.51		0.44		0.43		0.49

5.2 Inductive statistic

Inductive or inferential statistics conclude from data using statistical tests like one-way analysis of variance, which can be used to compare three groups (owners, consultants, and contractors).

5.2.1 Research hypotheses

The null hypothesis was assumed: There are no statistically significant differences among answers (owners, consultants, and contractors).

$H_o: \mu_O = \mu_{CS} = \mu_{CO}$ (5)

$H_a: \mu_O \neq \mu_{CS} = \mu_{CO}$ (6)

$H_a: \mu_O = \mu_{CS} \neq \mu_{CO}$ (7)

$H_a: \mu_O \neq \mu_{CS} \neq \mu_{CO}$ (8)

Where : H_o the null hypothesis, H_a an alternative hypothesis, μ_O mean dependent variable cause (variation orders) breakdown structure (CBS) from the owner's point of view, μ_{CS} mean dependent variable (CBS) from the consultant's point of view, μ_{CO} Mean dependent variable (CBS) from the contractor's point of view, $\alpha = 0.05 (statistical\ significance\ level\ 5\%)$.

If the sample size is more than 30, the data can be normally distributed (Shrestha and Maharjan, 2018). On this basis, a Parametric statistics test (ANOVA) was conducted among the independent variable (owners, consultants, and contractors) and the dependent variable cause (variation orders) breakdown structure (CBS). Statistical significance was level 5%. Table 10 shows the reasons for statistically significant differences between the answers of the sample members. Nevertheless, the post-test (Tukey's test) was conducted to determine differences among different groups' viewpoints (owners, contractors, and consultants).

Table 10. Differences among the answers of the sample members.

Dependent variable	Independent variable(I)	Independent variable(J)	Mean Difference (I-J)	ANOVA (p-value)	Post hoc. (p-value)
C.1.14	owner	consultant	0.20	0.008	.709
	contractor	owner	0.74		.013
	contractor	consultant	0.94		.013
C.2.1	owner	contractor	0.27	0.001	.540
	owner	consultant	0.95		.001
	contractor	consultant	0.67		.102
C.2.2	owner	contractor	0.17	0.008	.820
	owner	consultant	0.90		.005
	contractor	consultant	0.73		.122
C.2.3	owner	consultant	0.06	0.046	.981
	contractor	owner	0.74		.043
	contractor	consultant	0.79		.101
C.2.5	owner	contractor	0.33	0.023	.482

Dependent variable	Independent variable(I)	Independent variable(J)	Mean Difference (I-J)	ANOVA (p-value)	Post hoc. (p-value)
	owner	consultant	0.77		.021
	contractor	consultant	0.43		.466
C.2.6	owner	consultant	0.91	0	.001
	contractor	owner	0.39		.251
	contractor	consultant	1.30		.000
C.2.7	owner	consultant	0.85	0.006	.011
	contractor	owner	0.23		.712
	contractor	consultant	1.08		.012
C.2.8	owner	contractor	0.66	0	.052
	owner	consultant	1.53		.000
	contractor	consultant	0.87		.041
C.2.9	owner	contractor	0.59	0	.143
	owner	consultant	1.31		.000
	contractor	consultant	0.72		.162
C.2.10	owner	contractor	0.99	0	.001
	owner	consultant	1.07		.000
	contractor	consultant	0.07		.976
C.3.1	owner	contractor	0.24	0.008	.672
	owner	consultant	0.88		.005
	contractor	consultant	0.64		.181
C.3.2	owner	consultant	1.01	0	.000
	contractor	owner	0.08		.953
	contractor	consultant	1.08		.003
C.3.7	owner	contractor	0.64	0.019	.106
	owner	consultant	0.72		.053
	contractor	consultant	0.08		.977
C.3.8	owner	contractor	0.75	0	.019
	owner	consultant	1.28		.000
	contractor	consultant	0.53		.280

Dependent variable	Independent variable(I)	Independent variable(J)	Mean Difference (I-J)	ANOVA (p-value)	Post hoc. (p-value)
C.3.10	owner	contractor	0.33	0.001	.500
	owner	consultant	1.05		.001
	contractor	consultant	0.73		.122
C.4.1	owner	contractor	0.59	0.007	.032
	owner	consultant	0.54		.049
	consultant	contractor	0.05		.984
C.4.2	owner	contractor	0.79	0.001	.003
	owner	consultant	0.49		.088
	consultant	contractor	0.30		.571
C.6.7	owner	consultant	0.45	0.004	.114
	contractor	owner	0.54		.052
	contractor	consultant	0.99		.002
C.7.1	owner	contractor	0.33	0.001	.291
	owner	consultant	0.81		.001
	contractor	consultant	0.49		.180
C.12.7	owner	contractor	0.18	0.007	.725
	owner	consultant	0.75		.005
	contractor	consultant	0.56		.153

6. CONCLUSIONS

In conclusion, it would appear that the contract concluded in the construction of the buildings is the bill of quantities. In contrast, the lump sum is used on a small scale. The main conclusion that can be drawn was an agreement of viewpoints (owners, contractors, and consultants) on the critical causes of variation orders were :

The delay in the payment (c.1.5) – the challenging financial situation (c.1.6) - deficiency in checking project documentation (c.1.10) - modification specifications of material to benefit the project (c.7.4) - technical requirement (c.7.6) - construction necessity (c.7.7) - the absence of understanding among the project parties (c.9.1)- defeat to provide the modified designs within the limited time (c.9.2) - The nature of the worksite (c.11.1)- transgressors on the worksite (c.11.2) - the worksite situation (c.11.3), and emergency conditions (c.12.6).

Moreover, the point of view (owners and contractors) on the essential factors that cause change orders were :

A deficiency of experience and knowledge of materials in the market (c.2.7) - preparing a bill of quantities is inaccurate (c.2.8) - weak consultant estimate (c2.9) - shortage of clarity designs and specifications (c.3.1) - insufficient contract preparation (c.6.5) - inaccurate the contract review

(c.6.6) - contract does not involve all elements of the project (c.6.7) - unavailability of the required materials (c.7.1) - variation specifications of material for the benefit of the project (c.7.4) On the other hand, the consultant's point of view differs, as he considers these causes ineffective. It can be interpreted as the consultant seeing these factors as insignificant because of his duty to implement the bill of quantities and designs.

Finally, the contractor was the most advantageous party to issue a variation order, followed by the owner and the consultant. However, we have shown a complex causal relationship between the causes of variation orders, and their (RII) varies among the different parties (owner, contractor and consultant).

Future research could examine the causal interrelationship between the causes of variation orders according to three points of view owners, contractors, and consultants. Investigating the relationship of the variation order with the cost and type of contract of projects for public buildings is an interesting topic for future work.

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