

# Investigating Variation Orders Causes in Iraqi Building Construction Projects

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**Abstract.** Changes are a common phenomenon in the construction industry, impacting the project's cost, time, and performance. The purpose of this work is to a comprehensive review relating to variation order causes. Also, the aim here is to determine variation order causes in the building's construction. More importantly, explore the relationship between these causes. However, the importance of specifying the causes for change orders is the first step in managing variation orders to reduce the harmful effect on a project. The field survey was conducted for several institutions such as health (Karkh's health), higher education (University of Baghdad and University of Kufa). As a result, a field visit was made to the project sites. They were then, Conducting interviews with the resident engineer, the consultant, and the contractor. A developer tool called cause (variation orders) breakdown structure (CBS) included 12 causes at the first level, including 103 sub-causes. There is a relationship between the variation orders causes, which is evident in the third level. The study recommends adopting (CBS) a comprehensive reference for variation order causes in projects due to facilitating their management processes. Future research could examine the relative importance of variation order causes, in addition to using a fuzzy cognitive map to find the extent of each cause's influence on the other.

**Keywords:** Variation orders; cause (variation orders) breakdown structure (CBS); field survey.

## Introduction

The construction activity is complicated and conventionally fragmented; hence, it is nearly impossible to have a project closed without variations to an initial plan [1]. In other words, it indicates that it is unusual to deliver a project without any difference through its lifecycle [2]. Most contracts must involve terms for permissible variations given the construction project's characteristics [3]. Version orders are not novel to the construction industry, so the variation orders are considered the exclusive lawful means available to variation the contract requirements [4]. The variation orders causes are various, making the variation management challenge difficult for project owners. Therefore, it becomes necessary to review and analyze variation orders' causes to know their impacts on the project [1,5]. The expressions "Variation Order" implore negative feelings toward all concerned in projects. Owners do not wish them because they commonly suppose they are funding for other's errors.

on the other hand, contractors consider that variation orders obstruct work and require paperwork and time [6]. Nevertheless, it is generally that consultants accepted, contractors and owners agree that projects would be satisfactory in the absence of variation orders [7]. Change orders in any project adversely affect the project cost and schedule performance [8]. This is identified as the cumulative impact of change orders [9]. If no approval has arrived from project participants on the variation, it turns into a claim that influences its execution and affects its successful completion [10].

A variation order is one of the few mechanisms that the project manager should contractually have to accommodate unplanned events. It is necessary to have a project manager know the causes behind an unexpected change in the project and respond suitably until the project can be finished successfully [11]. Though, no unique method is available for managing or controlling them adequately. The conventional

practices involve a portion of the project budget as a reserve for their existence [12]. It was reported in the literature that analysis of change order causes due to (Owner -Contractor-Consultants-Other Causes) [10,13]. On the other hand, it is thought analysis (construction-administrative-resources) aspects [14]. According to [15], a hierarchical structure has been created for the change command reasons. It consists of Construction needs and Administrative needs). Variation is “Change or adjustment design, quality, or quantity of the works as illustrated in the contract drawings and defined by or related to in the bill of contract” [16]. Several researchers defined the variation order as:

- 1) It is work that added to or deleted from the original scope of work of a contract which alters the original contract amount or completion date [17].
- 2) The deviation experienced in any project from a base contract or work scope mutually agreed at contracting time [18].
- 3) It is written agreement between the contracting parties that represent an addition, deletion, or revision to the contract documents, identifies the change in price and time and describes the nature of the work involved [19].
- 4) The formal document that is used to modify the original contractual agreement provided to the contractor by the client or the client’s representative and becomes part of the project’s documents [20].
- 5) Legal documents that adapt to any additional work in a contract that was not included in the original contract [21].
- 6) Any change in the works where a change order is issued in respect thereof or approved as a change under the provisions of (Article Thirteen) [22]. The definition of variation orders will be given as an order issued by the contracting party (Owner) to make a variation in quantity, quality, and scope of work or any component of it. Variation orders deal with unexpected circumstances or, in the case of engineering assessment, to procedure an increase or decrease in quantities or delete or partial addition to working if there does an essential need for variation. Furthermore, the owner has the authority to issue a variation order. Also, the contractor is directed to implement it. This paper will focus on a comprehensive review relating to the variation order causes. Also, this study aimed to determine the variation order causes in a building’s construction. More importantly, Explore the relationship between these causes.

## Previous Studies

Alnuaimi et al. [12] examined changes in Oman’s public projects by studying changes causes, analyzing changes causes influences on the project, recognizing the beneficial parties, proposing solutions to relevant obstacles, and finding the owner’s extra works and design adjustments were the most critical factors variation orders causing. Pourrostan et al. [23] studied describing and assessing the causes and influences of variation orders and methods of variation orders control on construction projects in Iran. Their study revealed the contractor’s financial challenges, preceding construction delays by contractors working on various projects also the speedup of work are critical agents responsible for variation orders. Also, delay in completion schedule and extra income for a contractor is listed high by the respondents. Determining policies of variation orders control on building construction. Ismail et al. [24] argued the causes and examined change orders’ effects on Iran's roadway construction projects. Results showed the critical factors causing variation orders in the roadway: variation of scope or plans by owner, omissions and errors in design, contractor’s financial challenges, and differing site conditions. Time and cost factors established consequences of variation orders in construction projects. Shrestha et al. [8] conducted a statistically analyzing the number of change orders in new and modernization construction projects. The correlation analysis of new projects variation order metrics with contract award cost extension and whole cost growth explained no statistically significant correlation between these variables at  $\alpha$  equal to 0.05. The absence of correlation of variation order metrics with award cost growth refutes the assumption that

contractors attempt to compensate for their low bid price by creating more change orders throughout construction projects.

Alaryan et al. [25] studied the variation orders in Kuwaiti construction projects by conducting a survey and identifying the major variation orders causes and their influences on projects and controls. Indicated results that the owner is the party charged with causing variation. Furthermore, it identified that the first cause is a variation of plans through the owner. In other ways, the first impact on the project was an increment in the cost. Mohammed [13] identified the most important variation orders causes in various construction sectors in Erbil and their influences on the projects to manage them and suggested the resolutions that can reduce them through control measures. She found the owner and consultant were capable parties causing variations. Also; the most influential of change orders causes in projects were variation in the bill of quantities, change of plans or schedule by the owner, poor contractor background, poor consultant’s knowledge about the availability of equipment or materials, omissions design, and faults. Assbeihat et al. [26] found that causes variation orders to include the extended waiting time to get approval on designs, the variation of schedule by the owner, design complexity, absence of contractor’s engagement in design, obstructions in securing a site, site safety considerations, and equipment or materials scarce. Senouci et al. [27] recognized of causes and influences of variation orders and developed a structure for appraising the variation orders causes. Eltahir et al. [6] distinguished significant ten agents that cause change orders in the Sudani building project. The variation orders cause and their effect on the Iraqi construction projects, then interpreted the causes using data mining techniques [28,29]. More of the previous studies have examined the variation orders causes as independent causes. A variation in construction projects usually merges various Interconnected causes instead of a different cause.

### Methodology

In this study, the methodology can be shown in Figure 1. This study used different data collection methods such as literature reviewed and field survey. The methodology was achieved in several steps. Firstly, the literature on change orders was reviewed by scientific journals, documents, and books. Also, reviewed 120 scientific papers. Secondly, the field survey was conducted for several institutions such as health (Karkh’s health), higher education (University of Baghdad and University of Kufa). As a result, field visits were done to the project sites. Interviews Conducted with the resident engineer, the consultant, and the contractor. Thirdly, survey data were collected from previously implemented projects by studying the files and documenting change orders, their costs, and their impact on the project.

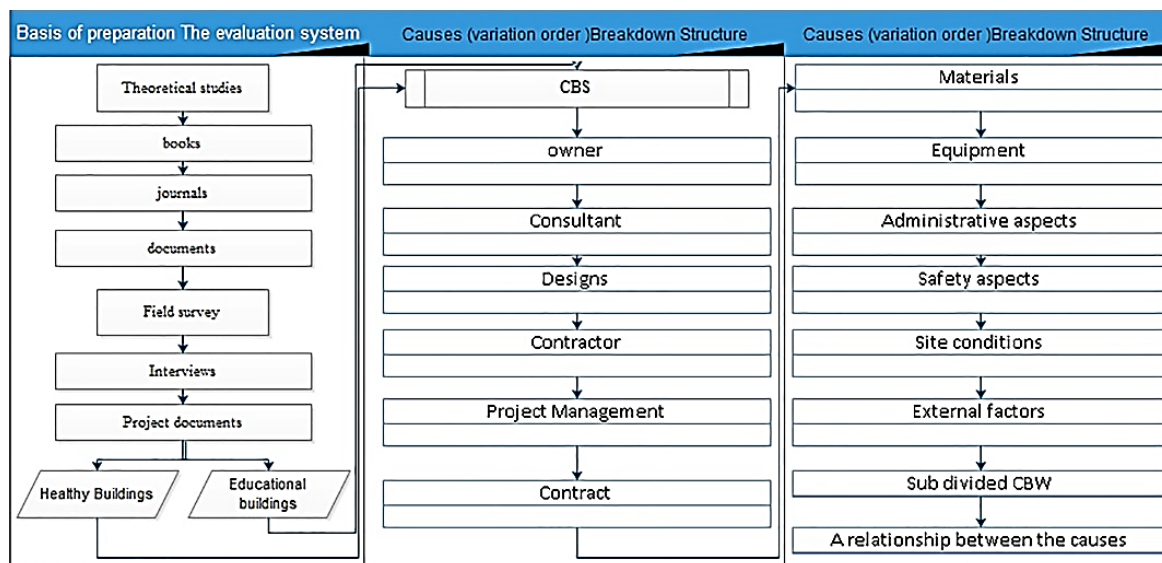


Figure 1. Flow chart of the methodology.

Finally, survey data included eleven case studies divided into three groups educational and health buildings. The first group consisting of projects (A1, A2, A3, A4, and A5), respectively, dealt with buildings in university Al Kufa while the second group included projects (B1, B2, and B3), sequentially, dealt with buildings in Karkh’s health whereas the third group involved projects (D1, D2, and D3), respectively, dealt with buildings in University of Baghdad. The data are presented in Table 1. However, according to our data, the change orders were analyzed to extract the causes for them using cause (variation orders) Breakdown Structure (CBS) by Primavera software (P6). Where the causes were divided into two levels (C), (C.m), (C.m.n), respectively, where (m=1,2...,12), (n=1, 2,...,n)..

## Results

It is apparent from Table 1 Health and educational projects and changes order amounts (Quantities Increase-Decrease quantities -Delete quantities - Create a task). Positive and negative change orders can be calculated from the equation (Eq 1, Eq 2). Frequently, the proposed by the researcher as follows:

$$\text{Change orders}(+) = \frac{(\text{quantities increase} + \text{create a task})}{\text{contract price}} \times 100 \quad (1)$$

$$\text{Change orders}(-) = \frac{(\text{Decrease quantities} + \text{Delete quantities})}{\text{contract price}} \times 100 \quad (2)$$

The result now provides evidence to projects (A1-A5) Change orders (+) and Change orders (-) Equations (Eq. 1 and Eq. 2). A small amount due to the change orders is few in contrast to other projects. The data in Tables 2 to 4 indicate a Hierarchical structure similar to the work breakdown structure is called cause (variation orders) Breakdown Structure (CBS). It is known as a tool representing the hierarchical structure of change order causes, and it is described from the first level to the third level (C, C1, and C2).

Table 1. The data of field survey.

Code	Project	Contract price ×10 <sup>6</sup> IQD	Change orders (+) %	Change orders (-) %	Quantities increase price ×10 <sup>6</sup> IQD	Decrease quantities price ×10 <sup>6</sup> IQD	Delete quantities price ×10 <sup>6</sup> IQD	Create clauses price ×10 <sup>6</sup> IQD
A1	Internal departments (female)	1900	1.0	0.0	19.3	0	0	0
A2	Dean of the Faculty of Arts	1255	1.5	1.8	14	0	22.5	4.5
A3	Dean of the College of Medicine	1920	0.3	0.0	4.55	0	0	1.5
A4	Internal departments (male)	1855	1.1	0.0	6	0	0	13.6
A5	College of Science Part 9 A and B.	3325	3.5	0.0	0	0	0	118
B1	Construct house resident doctors at Yarmouk Teaching Hospital	1716	25.7	31.6	250.35	100.8	442.102	190.99
B2	Demolition and construction of a health center	899.66	18.6	13.9	25.4	75.04	50.23	141.77
B3	Construct of a coordinated Tuberculosis	828.696	11.5	5.8	40.179	42.996	5.12	55.2
D1	Institute of a building genetic engineering	7865	9.8	3.0	539.993	233.431	0	228.01
D2	Construction of the College of Law	7865	11.0	4.6	667.567	362	0	195
D3	Construction of the College of Science for Girls	7733.66	6.4	2.1	402.467	163.289	0	93

Table 2. Variation orders analysis of CBS-C.1, C.2, and C.3.

<b>CBS Code</b>	<b>CBS Name</b>	<b>Reference</b>
<b>C</b>	<b>Causes change orders</b>	
<b>C.1</b>	<b>Owner</b>	
C.1.1	Schedule change	[30]
C.1.2	Scope change	[30]
C.1.3	Change in the Action Plan	[30]
C.1.4	Decision making is slow and complicated	[30]
C.1.5	The delay in the payment of the contracting parties	[30]
C.1.6	Difficult financial situation	[30]
C.1.7	The character of the owner is strict and inflexible	[10]
C.1.8	The goals of the project are incomplete	Field survey
C.1.9	Owner requirements incomplete	Field survey
C.1.10	Weakness in reviewing project documentation	Field survey
C.1.11	Owner requirements unclear	[31]
C.1.12	Job change in a project structure	Field survey
C.1.13	Weakness in project management	Field survey
C.1.14	Lack of owner experience	Field survey
C.1.15	Not to hand over the right site time for the contractor	Field survey
C.1.16	Change in the sequence of implementation	Field survey
C.1.17	Desire to start early in the project	[10]
C.1.18	Determine the time of activities is not suitable	Field survey
C.1.19	Change the decision-making authority frequently	Field survey
<b>C.2</b>	<b>Consultant</b>	
C.2.1	Lack of coordination between different specialization designers	[30]
C.2.2	Lack of consultant experience	[10]
C.2.3	The consultant was late in approving	[30]
C.2.4	Delayed in responding to problems	Field survey
C.2.5	Inflexible consultant personality	[30]
C.2.6	The weakness of supervision as a representative of the owner	[30]
C.2.7	Lack of knowledge of the presence of materials in the market	[10]
C.2.8	Weakness in preparing a bill of quantities	Field survey
C.2.9	Weak consultant guess	[10]
C.2.10	Inadequate identification of the logical relationship between the activities	Field survey
<b>C.3</b>	<b>Designs</b>	
C.3.1	Lack of clarity designs and technical specifications	[13]
C.3.2	Errors and omissions in designs	[30]
C.3.3	The level of complexity of designs	[30]
C.3.4	Insufficient design details to work	Field survey
C.3.5	Design inconsistency with regulations	Field survey
C.3.6	Designs not meeting the owner's requirements	[10]
C.3.7	The workshop layout is insufficient	Field survey
C.3.8	Errors and omissions in calculating quantities	[15]
C.3.9	Value engineering	[31]
C.3.10	Delay in reviewing designs (ambiguity in designs)	Field survey
C.3.11	Citation specification is not suitable for the project	[15]

Table 3. Variation orders analysis of CBS-C.4, C.5, C.5, and C.6.

<b>CBS Code</b>	<b>CBS Name</b>	<b>Reference</b>
<b>C.4</b>	<b>Contractor</b>	
C.4.1	Weak contractor management and supervision	[30]
C.4.2	Poor contractor planning and scheduling	[30]
C.4.3	Bad contractor financial position	[30]
C.4.4	The weakness of the contractor's work team	Field survey
C.4.5	Secondary contractors are ineffective	Field survey
C.4.6	Desire to make profits	[30]
C.4.7	Inadequate communication within the project parties	[30]
C.4.8	Delay in paying the dues of secondary contractors, suppliers	[30]
C.4.9	Delayed supply of resources	Field survey
C.4.10	Inadequate supply of resources and equipment to the site	Field survey
C.4.11	The complexity of designs by the contractor	[13]
C.4.12	Failure to coordinate with the employer supervising authority	[10]
C.4.13	Lack of productivity of the contractor's work team	[32]
<b>C.5</b>	<b>Project management</b>	
C.5.1	Lack of coordination between the parties	[13]
C.5.2	Poor communication	Field survey
C.5.3	Weak data available	[13]
C.5.4	The work progress schedule is unclear	Field survey
C.5.5	A change in project regulations	Field survey
C.5.6	Poor risk management	Field survey
C.5.7	Occupational safety procedures	Field survey
C.5.8	Weak field experience of the Resident Engineer	Field survey
C.5.9	Adhere to the routine procedures for approvals for the conduct of work	Field survey
<b>C.6</b>	<b>Contract</b>	
C.6.1	Conflict in the contract documents	[15]
C.6.2	Contract documents are unclear	[10]
C.6.3	The work scope is unclear within the contract	Field survey
C.6.4	Lack of contract documents	[10]
C.6.5	Poor contract preparation	Field survey
C.6.6	Inaccurate review of the contract	Field survey
C.6.7	The contract does not include all aspects of the project	Field survey
C.6.8	The contract is not appropriate, such as this type of work	Field survey
C.6.9	Terms of the contract contain unclear clauses	[15]
C.6.10	Corruption and suspicions in concluding contracts	[10]
C.6.11	Conducting the contract before the completion of the contract documents	Field survey
C.6.12	insufficient site investigation	[15]
<b>C.7</b>	<b>Materials</b>	
C.7.1	Unavailability of the required materials	[32]
C.7.2	Material failure in laboratory testing	Field survey
C.7.3	Delay in arrival of materials	Field survey
C.7.4	Change material specifications to benefit the project	Field survey
C.7.5	Change materials to achieve the exact specifications and lower prices	Field survey
C.7.6	Technical necessity	[10]
C.7.7	Constructive necessity	Field survey
C.7.8	Poor transportation of materials in the project	[32]
C.7.9	Poor management of materials on site	[32]

Table 4. Variation orders analysis of CBS-C.8, C.9, C.10, C.11, and C.12.

<b>C.8</b>	<b>Equipment</b>	
C.8.1	Insufficient equipment and tools	Field survey
C.8.2	Use obsolete equipment and tools	Field survey
C.8.3	Failure of equipment to perform its work	[31]
C.8.4	The poor performance of the equipment	[32]
C.8.5	Equipment break down when performing work	[32]
<b>C.9</b>	<b>Administrative aspects</b>	
C.9.1	The lack of understanding between the project parties	[32]
C.9.2	Failure to provide the revised designs with the specified time	[32]
C.9.3	Poor communication between workers and management	[32]
C.9.4	Poor Administrative	Field survey
C.9.5	Weakness in decision-making	[32]
C.9.6	Municipal regulations and urban planning	Field survey
C.9.7	Review the insurance regulations and the environmental protection	[15]
C.9.8	Fire fighting regulations and waste management regulations	[33]
C.9.9	Regulations for Archeology, roads, and electricity	[15]
<b>C.10</b>	<b>Safety aspects</b>	
C.10.1	Safety procedures and policies not sufficient on-site	[10]
C.10.2	Site safety considerations	[15]
<b>C.11</b>	<b>Site conditions</b>	
C.11.1	The nature of the site	[15]
C.11.2	Transgressors	Field survey
C.11.3	the site situation	[13]
C.11.4	Uncertainty problems of the land site	[30]
C.11.5	Available workspace	Field survey
<b>C.12</b>	<b>External factors</b>	
C.12.1	Environmental conditions	[32]
C.12.2	Economic conditions	[10]
C.12.3	Political legislation	[10]
C.12.4	Third-party actions	[10]
C.12.5	Force Majeure	Field survey
C.12.6	Emergency conditions	Field survey
C.12.7	Accidents	[13]
C.12.8	Damage to the interests of people outside of the parties to the project	Field survey
C.12.9	Political conditions	[15]
C.12.10	Cultural conditions	Field survey

## Conclusions

This study's findings can be understood as more Change orders (-) increases, Change orders (+) leads to a negative impact on the project. From this study, it was determined to change order causes in the building construction. Nevertheless, we found a developer tool called cause (variation orders) Breakdown Structure. (CBS) As it included 12 causes at the first level, and it includes 103 sub-causes. Results provide a basis for a relationship between the causes for the variation orders. This is evident in the third level. For example, when changing schedules (c.1.1) by the owner leads to a change in scope (C.1.2), which leads to the lack of sufficient labor for a contractor (C.4.13). In addition to the consultant not understanding the owner's requirements (C.2.11). As a result, it leads to change order. However, previous studies dealt with the factors causing change orders as independent factors without addressing the mutual effect. The study recommends adopting. (CBS) as a comprehensive guide for change orders causes in construction projects due to facilitating their management processes. Future research could examine the relative importance of variation orders causes. Using a fuzzy cognitive map to find the extent of each cause's influence on the other, which management of change orders is facilitated.

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