

Research Article

Exploring the Impacts of Change Orders on Performance of Construction Projects in Saudi Arabia

Majed Alzara 

Department of Civil Engineering, College of Engineering, Jouf University, Sakakah, Saudi Arabia

Correspondence should be addressed to Majed Alzara; alzaramajed@gmail.com

Received 29 March 2022; Revised 16 August 2022; Accepted 23 September 2022; Published 10 October 2022

Academic Editor: Jianyong Han

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The construction industry is one of the most complex industries, and it involves numerous change orders. Change orders often occur in all or some phases of industrial construction work and have a significant impact on the success of the project, its on-time completion, or ultimately, an increase in the estimated cost of the project. Change orders are one of the most frequently common problems facing construction projects in Saudi Arabia. The purpose of this study is to examine the impacts of change orders on construction projects in Saudi Arabia and identify preventive solutions to mitigate these impacts. To achieve this objective, the effects of change orders on construction projects in general were identified through a comprehensive literature review. Then, an analytical study was conducted on five construction projects in diverse universities in Saudi Arabia. Following that, interviews were conducted with some experts in these projects. Finally, a survey was conducted by distributing questionnaires to the parties involved in the projects, and the responses were analyzed by using the relative index method. A triangulation technique involving collecting data from the analytical study, the interviews, and the survey was used to improve the validity of the findings. The results showed that the major impacts of change orders on construction projects in Saudi Arabia were on meeting the needs of the project, disputes among parties of the project, and the development of project specifications. A set of preventive solutions were suggested to mitigate these impacts, such as having all parties study the project and coordinate between them before starting the project and hiring a specialized consultant with experience in similar projects.

1. Introduction

A contract change order (CCO) is common in construction projects in general, whether it is a building project or an infrastructure project. The change order is a form of work improvement often mentioned in the work contract. It has a direct effect in cases of project delay or cost overruns [1]. Changes or improvements to the scope of projects are often necessary and inevitable, leading to change orders being issued.

According to Luke J Farkey [2], the types of change orders in construction projects can be classified into three main types, with each type including different contractual reversals: additive change orders, deductive change orders, and partial termination. First, additive change orders are the most common change order. The contractor requests an increase in the project cost or schedule as a result of

assigning him additional tasks. Second, the deductive change order leads to the deletion of a specific part of the work, which in turn leads to a reduction in the total cost or time of the project. Third, partial termination involves a significant change in the scope of work. The contractor may delete large portions of the work scope, eventually leading to the invalidity of the contract. Construction contracts usually include language to allow partial termination.

Previous studies related to the classification of change orders (e.g., [3]) classified change orders into two categories: “anticipated change orders” and “emergent change orders.” Anticipated change orders can be planned in advance, whereas emerging change orders occur suddenly. The abovementioned study also stated that it is possible to classify change orders according to the necessity of changes: “required changing” indicates a necessity to implement changes in the project, and “elective changing” requires

TABLE 1: The effects of change orders from reviewed studies.

		[14]	[18]	[17]	[16]	[15]	[19]	[12]
1	Time overrun	✓	✓	✓	✓	✓	✓	
2	Cost overrun	✓	✓		✓	✓	✓	✓
3	Increase in overhead expenses	✓	✓	✓	✓	✓		✓
4	Delay in payment		✓		✓	✓		
5	Quality degradation	✓	✓	✓	✓	✓	✓	✓
6	Productivity degradation	✓	✓	✓	✓	✓	✓	✓
7	Procurement delay			✓	✓			
8	Rework and demolition	✓	✓	✓	✓	✓	✓	✓
9	Logistics delays			✓				
10	Safety consideration	✓			✓			
11	Additional payments for contractor	✓	✓		✓	✓	✓	✓
12	Disputes among parties	✓	✓	✓	✓	✓		

TABLE 2: Summary of the studied projects.

Project id	Project name	No. Of CO	% of CO	Original cost	Actual cost	Original time (days)	Actual time	Cost deviation	Time deviation (days)
Project A	College of administration and humanities project	5	8	61,342,235.41	66,076,776.81	356	900	4734541.4	544
Project B	College of preparatory year project	2	4.37	95,788,061.45	71,042,350.3	915	1647	-24,745,711.15	732
Project C	Infrastructure project	1	10	95,422,420	104,964,628	365	620	9,542,208	255
Project D	Theater and ballroom project	1	14.69	76,937,679.48	71,803,380.11	540	1629	-5,134,299.37	1089
Project E	Central library, restaurants, and support services project	10	16.22	116,590,752	118,474,148.1	915	1850	1,883,396.1	935

choosing between implementing or not implementing change orders. Change orders can be classified into “beneficial changing” and “detrimental change orders.” According to one study [4], if there is a need to improve work quality standards, reduce project costs, or compress the project schedule, a change order may be beneficial and may eliminate unnecessary costs. In contrast, there are some change orders that negatively affect the performance and quality of the project. Such orders are classified as “detrimental change orders.” Previous studies have shown that there are many reasons for change orders in construction projects [5, 6]. These studies categorized the causes of change orders into design-related causes, sudden changes in circumstances, and design-error-related causes. According to some studies [7–9], it is possible to classify changes on the basis of the sources of the changes, which are often represented by the contracting parties—namely the owner, the design consultant, the contractor, and other relevant parties. Some researchers [10] believe that changes in the scope of a project by the owner are the main reason for changes to the project itself. Errors in the project design are also a major reason, followed by reasons related to materials and labor. All of these can lead to the cost of the project increasing and the project schedule changes.

One study [11] examined 145 change orders for some projects, concluding that the largest percentage of change orders is due to errors or omissions in the work plan. This

percentage is approximately 52%. Meanwhile, 33% of change orders are due to changes in the plan by the owner, and 9% of change orders are due to unforeseen circumstances.

The aim of this research is to identify the impacts of change orders in construction projects in Saudi Arabia and to suggest preventive solutions to mitigate these impacts. To achieve the goal of the study and in view of the wide scope and multiplicity of construction projects in Saudi Arabia, case studies were conducted for some selected projects in diverse universities in Saudi Arabia. These projects varied in scope from educational buildings to infrastructure projects. This study also obtained the opinions of experts in construction projects in Saudi Arabia about the impacts of change orders and their suggestions to mitigate these impacts. To expand the scope of the study and achieve its objectives, a questionnaire survey was conducted and distributed to the parties involved in the construction projects (client, consultant, and contractor). Then, an analytical study was conducted to obtain their responses.

2. Statement of the Problem

There is always an impact of change orders on project performance, specifically project cost and schedule, which causes multiple problems among contracting project parties, including clients, consultants, and contractors.

TABLE 3: Extract carried out on the impacts of change orders in the studied projects.

Project A	Project B	Project C	Project D	Project E
Cost overrun of the project	Meeting the needs of the project	Cost overrun of the project	Meeting the needs of the project	Cost overrun of the project
Time overrun of the project	Time overrun of the project	Time overrun of the project	Time overrun of the project	Time overrun of the project
Delay in payment to the contractor	Developing the project specifications	Delay in payment to the contractor	Developing the project specifications	Delay in payment to the contractor
Developing the project specifications	Disputes among parties of the project	Developing the project specifications	Disputes among parties of the project	Developing the project specifications

TABLE 4: List of the interview results with the experts.

The question	The experts' responses
Discussing the impacts of change orders on the performance of construction projects in Saudi universities	<p><i>There are positive effects of change orders, such as</i></p> <ul style="list-style-type: none"> (i) Meeting the needs of the project owner (ii) Developing specifications due to lengthy implementation or award procedures (iii) Activating value engineering during implementation, which may help to achieve savings in cost and quantity <p><i>There are negative effects of change orders, such as</i></p> <ul style="list-style-type: none"> (i) Wrongly using change orders, leading to fraud by one of the project parties (ii) Increasing the project schedule, affecting the purpose of the project (iii) Increasing the final cost of the project.
Discussing the possible solutions to reduce change orders in construction projects	<ul style="list-style-type: none"> (i) Defining the goal and purpose of the project accurately before preparing the project designs (ii) Setting design criteria and performing clear calculations and studies for the project (iii) Requiring the designer to visit the site and the beneficiaries of the project to correctly identify the project needs (iv) Giving the designer a sufficient amount of time to study and develop appropriate, clear, and detailed specifications (v) Coordinating with the relevant authorities to determine requirements, including civil defense, electricity company, water company, Ministry of Transport, and information technology requirements (vi) Nonspecialization should not contribute for adding some modifications that affect the progress of the project need for a supervisory department with the expertise to review designs and approve it
Discussing how to mitigate the impacts of change orders on the performance of construction projects in Saudi universities	<ul style="list-style-type: none"> (i) All parties should study the project well and coordinate among themselves before starting the project. (ii) Periodic reviews should be conducted of the project according to need. (iii) One change order should be issued covering all aspects of the shortfall. (iv) A specialist consultant with expertise that reflects his technical capabilities should be chosen (v) Documents and standard controls should be developed to define the stages from the beginning of the project to its completion (vi) A common database system among all project parties should be developed

These problems appear clearly in construction projects in Saudi Arabia, which have a large scope and involve multiple companies and contractors. These construction projects often impose a binding schedule on all project parties.

2.1. Research Questions

- (1) What are the impacts of change orders on the performance of construction projects in Saudi Arabia?

TABLE 5: The final form of the questionnaire.

Section	S. N.	Question	Responses				
A	1	The job (contractor/engineer/consultant/other)					
	2	Employer (government entity/private sector/other)					
	3	Specialization					
	4	Number of years of experience in construction projects (less than 5 years/5 to 10 years/more than 10 years)					
B	S. N.	Impact of change orders on construction projects	No impact	Low impact	Medium impact	High impact	Very high impact
	1	Time overrun of the project					
	2	Cost overrun of the project					
	3	Increase in overhead expenses					
	4	Delay in payment to the contractor					
	5	Quality degradation in the project					
	6	Productivity degradation in the project					
	7	Demolition and rework					
	8	Safety considerations in the project					
	9	Additional payments for the contractor					
	10	Disputes among parties of the project					
	11	Meeting the needs of the project					
	12	Developing the project specifications					
		Other impacts (please indicate if any)					
C	S. N.	Factors that mitigate the impacts of using change orders in projects	No importance	Low importance	Medium importance	High importance	Very high importance
	1	All parties should study the project well and coordinate among themselves before starting the project					
	2	Periodic reviews of project requirements should be conducted as needed					
	3	A specialized consultant with experience in the project should be present					
	4	Software should be used to share data and business developments among all project parties					
	5	The use of change orders in the project should be minimized					
	6	There should be no reliance on the specifications of similar projects, and spatial considerations for each project should be considered					
		Other factors (please indicate if any)					

(2) What are the preventive solutions to mitigate the effects of change orders in construction projects in Saudi Arabia?

(iii) To identify preventive solutions that can be taken to mitigate the effects of these change orders on these types of construction projects

3. Research Objectives

The overall objective is to identify the impacts of change orders on the performance of construction projects in Saudi Arabia.

The specific objectives are as follows:

- (i) To identify the impacts of change orders in a sample of construction projects in diverse universities in Saudi Arabia
- (ii) To analyze the impact of these change orders on construction project performance, including cost and duration of completion of the projects

4. Literature Review

Chen [12] conducted an analytical study of a large sample of 1,071 construction projects to examine the effect of change orders on project performance. The percentage of residential buildings in these projects was about 17%. The remaining 83% consisted of infrastructure projects. The study concluded that change orders had a clear impact on the cost of the projects. The average cost increased on an average of by 8.45% of the original cost of the project, which negatively affected the project's performance. Ming et al. [3] explained that a change in the works of construction projects usually

TABLE 6: Frequency of impact of change orders on projects.

Impact of change orders	Consultant responses		Contractor responses		Engineers responses		Overall responses	
	RI	Rank	RI	Rank	RI	Rank	RI	Rank
Meeting the needs of the project	0.62	1	0.37	11	0.44	8	0.75	1
Disputes among parties of the project	0.43	10	0.47	6	0.45	7	0.73	2
Developing the project specifications	0.52	5	0.49	5	0.39	9	0.73	3
Time overrun of the project	0.55	3	0.46	7	0.55	1	0.70	4
Cost overrun of the project	0.51	6	0.60	2	0.54	2	0.70	5
Increase in overhead expenses	0.51	7	0.50	4	0.54	4	0.70	6
Delay in payment to the contractor	0.55	4	0.30	12	0.48	5	0.70	7
Demolition and rework	0.51	8	0.40	9	0.46	6	0.66	8
Additional payments for the contractor	0.43	9	0.53	3	0.54	3	0.64	9
Productivity degradation in the project	0.57	2	0.64	1	0.38	10	0.59	10
Quality degradation in the project	0.38	11	0.46	8	0.22	12	0.56	11
Safety considerations in the project	0.28	12	0.40	10	0.35	11	0.50	12

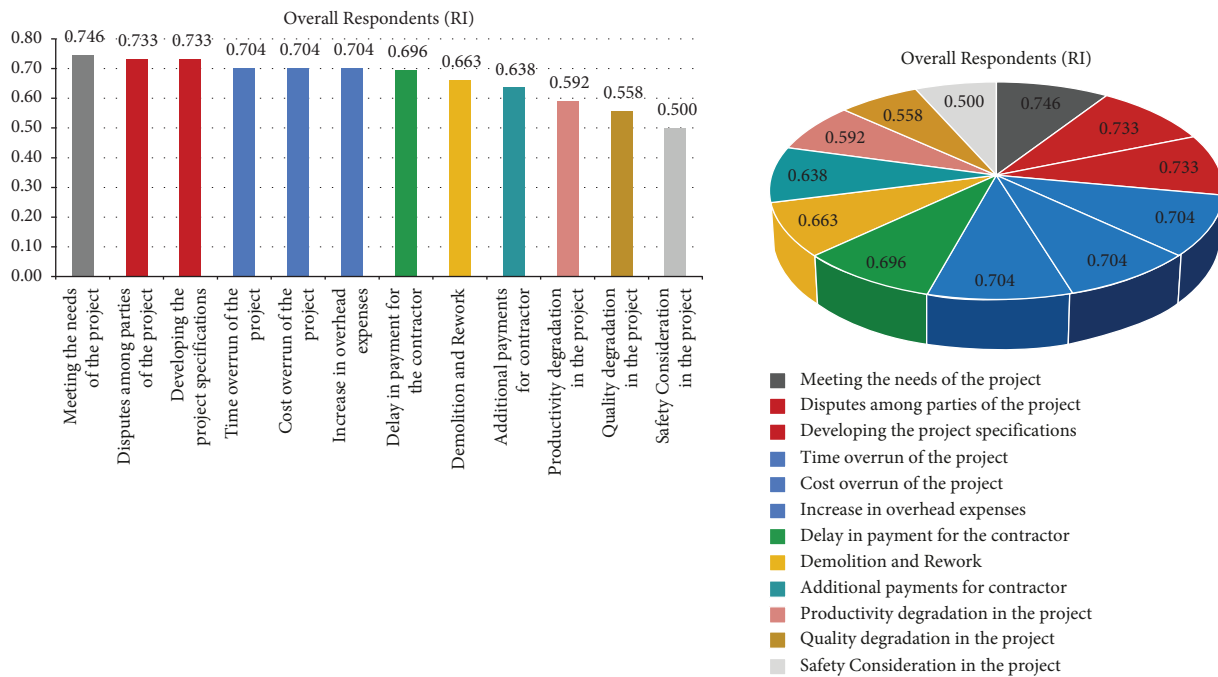


FIGURE 1: Frequency of impact of change orders on projects (overall responses).

occurs as a result of a change in the design or aspects of the project. The latter change is due to modifications in pre-existing conditions or requirements. If the number of change orders is increased in a project, this may result in a misunderstanding between the contracting parties, leading to a variation in costs or a delay in work completion. There may also be a conflict of work between the project parties, affecting the project schedule. According to Ruben [13], change orders affect overall project performance.

Regarding construction projects in educational institutions such as universities, studies have specifically addressed this type of project. According to Arain and Pheng [9], changes in design are the most important reasons for change orders in 70 educational projects. Oyewobi [14] identified 14 main factors as reasons for change orders in educational projects. The effects of these change orders were felt most on cost, time, customer dissatisfaction, and rework and

demolition. There were also cases of contract termination. The average cost overrun in these projects was 33.95%, and the average delay in project time was 29.45%.

Researchers [14–29] have reviewed studies to determine the impact of change orders on projects. According to these authors, the various impacts of change orders were as follows: time overruns, cost overrun, increase in overhead expenses, delay in payment, quality degradation, productivity degradation, procurement delay, rework and demolition, logistics delays, safety consideration, additional payments for the contractor, and disputes among parties. Table 1 presents the effects of change orders from the reviewed studies.

From previous studies, it is clear that change orders and their repetition strongly affect the performance of a project based on various factors, some of which may be expected in advance and others may not.

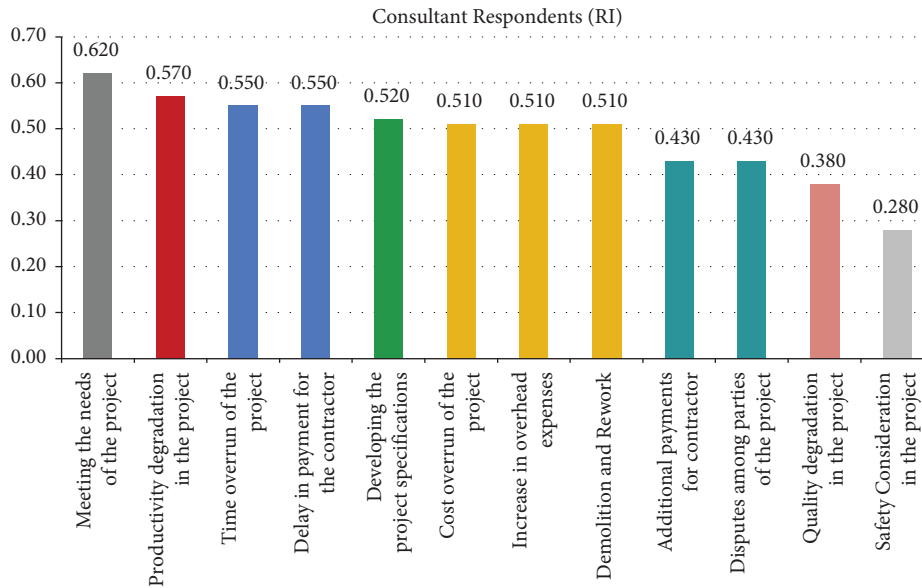


FIGURE 2: Frequency of impact of change orders on projects (consultants' responses).

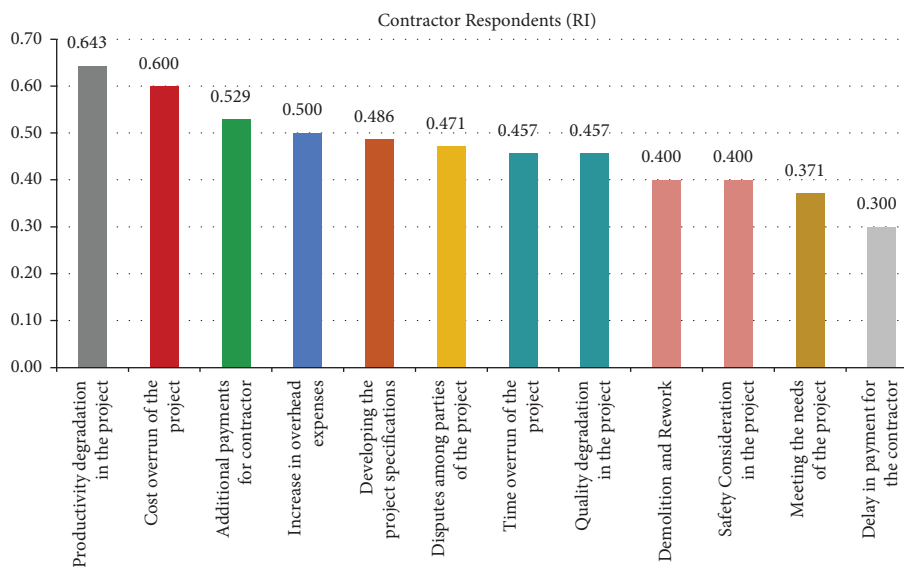


FIGURE 3: Frequency of impact of change orders on projects (contractors' responses).

5. Methods

The aim of the study was to identify the impacts of change orders in construction projects in Saudi Arabia. Primary data were collected through a literature review to determine the most impacted areas in construction projects. A case study was conducted on five newly completed construction projects (universities) in Saudi Arabia. Detailed information was collected, such as (weekly and monthly reports, contract value, number of change orders, project schedule, and impact of change orders on the performance of projects in time and cost). Next, interviews were conducted with experts to obtain their opinion on how change orders can affect construction projects and how to mitigate these effects. Finally, a quantitative questionnaire was administered to the project parties in Saudi

Arabia to obtain the opinions of specialists about the effects of change orders on construction projects in Saudi Arabia.

6. Results and Discussion

In this part, the data of the studied projects will be considered and analyzed. Additionally, the results of the interviews conducted with the specialists will be discussed. Finally, the responses received from the specialists through the questionnaires will be analyzed.

6.1. Case Study Result. To further understand the impact of change orders on construction projects in Saudi Arabia, a case study of five projects in diverse universities in Saudi

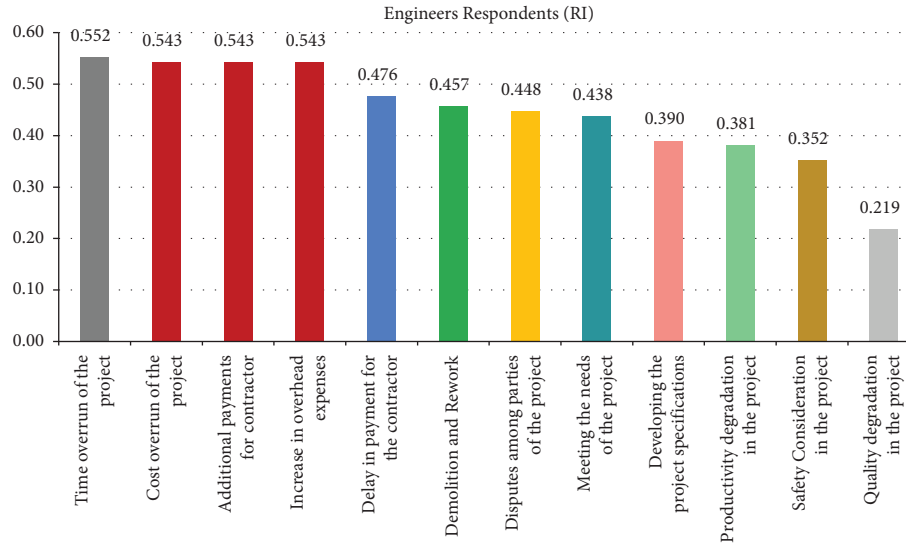


FIGURE 4: Frequency of impact of change orders on projects (Engineers’ responses).

TABLE 7: The five most important impacts of change orders.

Rank	Consultants’ responses	Contractors’ responses	Engineers’ responses
1	Meeting the needs of the project	Productivity degradation in the project	Time overrun of the project
2	Productivity degradation in the project	Cost overrun of the project	Cost overrun of the project
3	Time overrun of the project	Additional payments for contractor	Additional payments for contractor
4	Delay in payment to the contractor	Increase in overhead expenses	Increase in overhead expenses
5	Developing the project specifications	Developing the project specifications	Delay in payment to the contractor

TABLE 8: The most important factors that mitigate the impacts of change orders on projects.

Impact of change orders	Consultants’ responses		Contractors’ responses		Engineers’ responses		Overall responses	
	RI	Ranking	RI	Ranking	RI	Ranking	RI	Ranking
All parties should study the project well and coordinate among themselves before starting the project	0.954	1	0.971	1	0.781	1	0.967	1
A specialized consultant with experience in the project should be present	0.892	2	0.900	2	0.733	2	0.904	2
Periodic reviews of project requirements should be conducted as needed	0.877	3	0.829	4	0.657	5	0.842	3
There should be no reliance on the specifications of similar projects, and spatial considerations for each project should be considered	0.8	5	0.843	3	0.610	6	0.800	4
Software should be used to share data and business developments among all project parties	0.785	6	0.729	6	0.705	3	0.779	5
The use of change orders in the project should be minimized	0.831	4	0.786	5	0.705	4	0.779	6

Arabia was conducted. These projects were completed in the last three years and varied from educational building projects to infrastructure projects. Table 2 shows the average values of the original project cost and the actual cost, the original project time and actual time, and the number and percentage of the change orders in all projects.

Projects (A) to (E) were exposed to project cost overruns of 7.72%, -25.38%, 10.00%, -6.67%, and 1.62% of the contract amount, respectively. The summary of the impacts of change orders is provided in Table 3.

6.2. Interview Result. The interviews were conducted with carefully selected experts on construction projects in Saudi Arabia. The aim was to determine the impacts of change orders on the performance of these projects as well as to investigate how to mitigate these impacts.

The results of the interview showed that there are common effects of change orders. These effects frequently occur, whether by increasing the final cost of the project or delaying the project schedule. Some disputes between parties and some degradation in quality also occur. In some cases, a

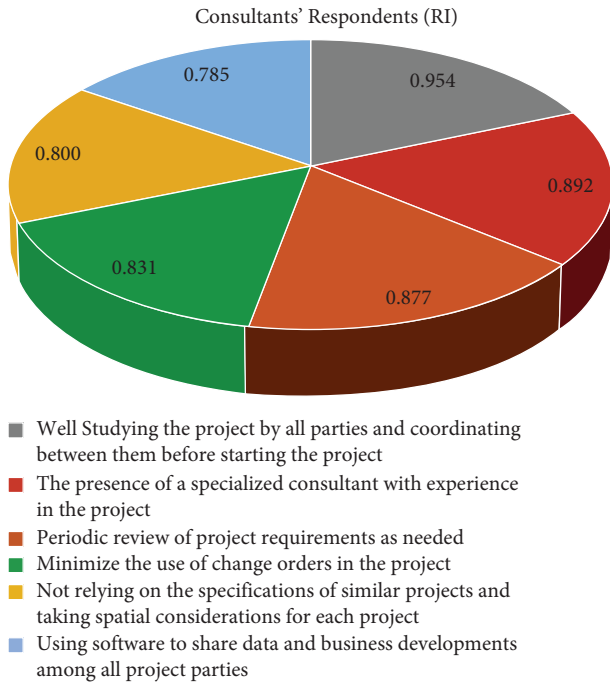


FIGURE 5: The most important factors that mitigate the impacts of change orders (consultants' responses).

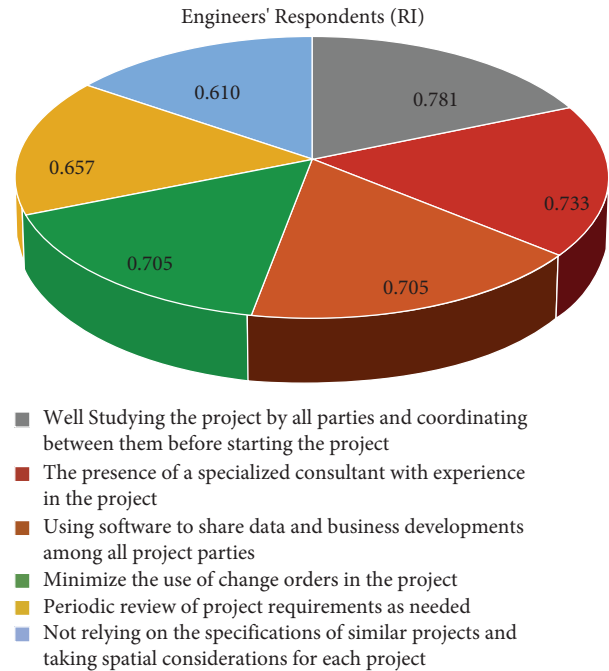


FIGURE 7: The most important factors that mitigate the impacts of change orders (engineers' responses).

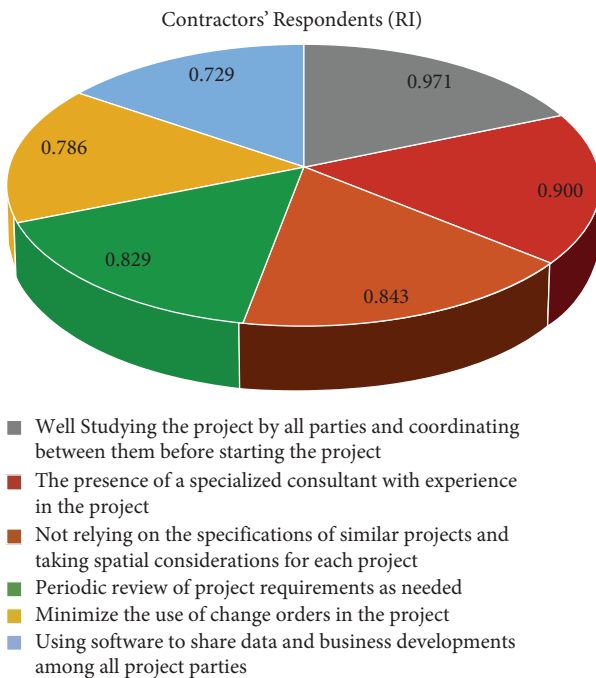


FIGURE 6: The most important factors that mitigate the impacts of change orders (contractors' responses).

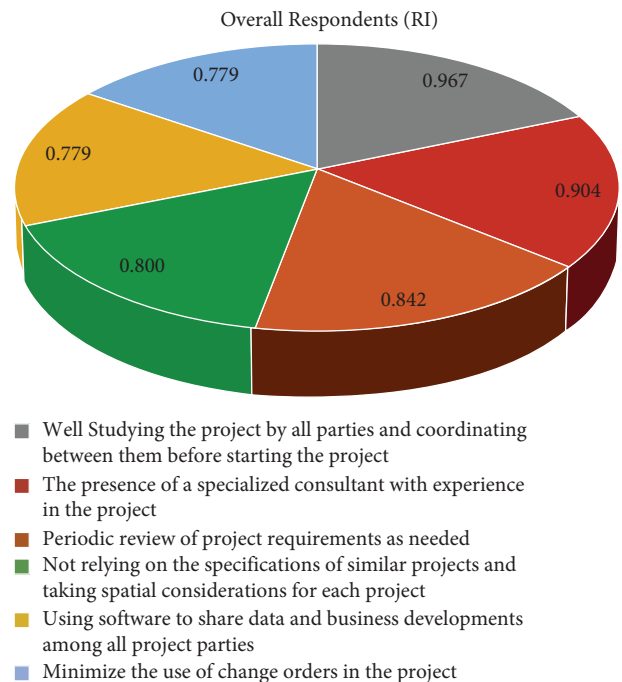


FIGURE 8: The most important factors that mitigate the impacts of change orders (overall responses).

partial withdrawal of work may occur. Table 4 summarizes these effects. The experts agreed on how to mitigate these effects, and their recommendations are discussed herein.

6.3. *Questionnaire Survey Result.* The questionnaire form was divided into three sections. The first section included general information about the respondents and their

experiences, the second section was about the impact of change orders on the performance of construction projects, and the third section concerned respondents' opinions on how to mitigate the impact of the change orders on the performance of diverse construction projects. The responses were arranged by using a Likert scale from 1 (no impact) to 5 (very high impact). As Table 5 shows, 12 impacts of change

TABLE 9: The most important factors that mitigate the impacts of change orders on construction projects.

Rank	Consultants' respondents	Contractors' respondents	Engineers' respondents
1	All parties should study the project well and coordinate among themselves before starting the project	All parties should study the project well and coordinate among themselves before starting the project	All parties should study the project well and coordinate among themselves before starting the project
2	A specialized consultant with experience in the project should be present	A specialized consultant with experience in the project should be present	A specialized consultant with experience in the project should be present
3	Periodic reviews of project requirements should be conducted as needed	There should be no reliance on the specifications of similar projects, and spatial considerations for each project should be considered	Software should be used to share data and business developments among all project parties

orders on construction projects were identified from the literature review and expert interviews.

The results of the questionnaire were collected, and the respondents were divided into three main divisions: consultants, contractors, and engineers. A total of 140 questionnaires were distributed to the targeted respondents; 98 were completed and returned, indicating a 70% response rate.

The results of the responses were analyzed according to the relative index method (RI) to determine which factors were more important for each of the three sections (consultant, contractor, and engineers). A higher RI value indicated an increase in urgency.

$$RI = \frac{(5n_5 + 4n_4 + 3n_3 + 2n_2 + n_1)}{5(n_5 + n_4 + n_3 + n_2 + n_1)}, \quad (1)$$

where *RI*: relative index; n_5 , n_4 , n_3 , n_2 , and n_1 : number of responding indices.

6.3.1. The Impacts of Change Orders on Construction Projects. As Table 6 and Figure 1 show, the highest ranked impact of change orders according to the overall responses was "Meeting the needs of the project" (RI = 0.746), followed by "Disputes among parties of the project" (RI = 0.734) and "Developing the project specifications" (RI = 0.734). "Time overrun," "Cost overrun," and "Increase in overhead expenses" had the same impacts on the project (RI = 0.704). The lowest ranked impact of change orders according to the overall responses was "Safety consideration in the project" (RI = 0.5). Figures 2–4 show responses from the project parties (consultants' responses, contractors' responses, and engineers' responses).

Based on Figures 1–4, the five most important impacts of change orders on construction projects are illustrated in Table 7.

6.3.2. Factors That Mitigate the Impacts of Using Change Orders in Projects. As Table 8 shows, the most important factor that mitigated the impacts of using change orders in projects was "All parties should study the project well and coordinate among themselves before starting the project" (RI = 0.967). The least ranked factor according to the overall responses was "The use of change orders in the project should be minimized" (RI = 0.779) (Figures 5–8).

Based on Figures 5–8, the three most important factors that mitigate the impacts of change orders on construction projects are illustrated in Table 9.

7. Conclusions and Recommendations

This study focused on the effects of change orders on construction projects in Saudi Arabia. Analytical data were collected using four methods. Data were collected and classified based on a literature review. Then, a case study was conducted of five recently completed projects in diverse Saudi universities. Interviews were also conducted with experts to determine their opinion about how change orders can affect construction projects and how to mitigate these effects. Finally, a quantitative questionnaire was administered to parties in construction projects in Saudi Arabia to assess the opinions of specialists about the effects of change orders on construction projects in Saudi Arabia.

Based on the findings of the study, the following conclusions were obtained:

- (i) The most ranked impact of change orders on construction projects in Saudi Arabia was "Meeting the needs of the project" (RI = 0.746). This was followed by "Disputes among parties of the project" (RI = 0.734) and "Developing the project specifications" (RI = 0.734). "Time overrun," "Cost overrun," and "Increase in overhead expenses" had the same impacts on the project (RI = 0.704). The lowest ranked impact of change orders according to the overall responses was the "Safety consideration in the project" (RI = 0.5).
- (ii) The most important factor that mitigated the impacts of using change orders on construction projects in Saudi Arabia was "All parties should study the project well and coordinate among themselves before starting the project" (RI = 0.967). This was followed by "A specialized consultant with experience in the project should be present" (RI = 0.904), "Periodic reviews of project requirements should be conducted as needed" (RI = 0.842), and "There should be no reliance on the specifications of similar projects, and spatial considerations for each project should be considered" (RI = 0.8). "Software should be used to share data and business developments among all project parties" and "The use of change

orders in the project should be minimized” had the same impacts on the project (RI = 0.779).

The following ideas are recommended to improve the management of construction projects in Saudi Arabia:

- (i) All project parties must have sufficient awareness of the negative and positive impacts of change orders on the performance of construction projects.
- (ii) Project parties should implement identified measures to control the impacts of change orders, such as defining the goal and purpose of the project accurately before preparing the designs for the project, setting design criteria, and performing clear calculations and studies for the project. These can be achieved by engaging competent professionals in the project team and ensuring their adequate participation.
- (iii) Periodic coordination plans should be implemented among all parties to make the best use of change orders.
- (iv) The client should have a clear vision of the extent of the project and be careful in selecting the consultant.
- (v) The relevant authorities should coordinate to determine the requirements before starting the project, including civil defense, electricity company, water company, Ministry of Transport, and information technology requirements. The designer should visit the site as well as meet the beneficiaries of the project and correctly identify their needs. The designer should take a sufficient amount of time to study and develop appropriate, clear, and detailed specifications for the project.
- (vi) A supervisory department with the expertise to review designs and approve them should be set up.

Abbreviations

CO: Change orders
 CCO: Contract change orders
 RI: Relative index
 n : Number of responding indices.

Data Availability

The data used to support the findings of this study are available upon request from the corresponding author.

Consent

All participants in this study are aware of the purpose of the study and have given their consent to participate.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

Dr. Majed Alzara has collected the data, conceived and performed the analyses, validated and discussed the results, and written the paper.

References

- [1] M. Y. Tuloli, A. Utiahman, and M. P. Palilati, "Analysis of causes and impact of variation order in the education building project in gorontalo province," *IOP Conference Series: Materials Science and Engineering*, vol. 1098, no. 2, Article ID 022065, 2021.
- [2] S. Luke J Farkey, *The Basics of Change Orders*, ABA Forum Constr. Law, Memphis, 2018.
- [3] S. Ming, S. Martin, and A. Chimay, *Managing Changes in Construction Projects. Ind. Report*, University West England, Bristol, 2004.
- [4] F. M. Arain and L. S. Pheng, "How design consultants perceive potential causes of variation orders for institutional buildings in Singapore," *Architectural Engineering and Design Management*, vol. 1, no. 3, pp. 181–196, 2005.
- [5] J. E. Diekmann and M. C. Nelson Construction Claims, "Frequency and severity," *Construction Engineering and Management*, vol. 111, 1985.
- [6] C. W. Ibbs, "Quantitative impacts of project change: size, issues," *Journal of Management in Engineering*, vol. 123, pp. 308–311, 1997.
- [7] P. Keane, B. Sertyesilisik, and A. D. Ross, "Variations and change orders on construction projects," *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 2, pp. 89–96, 2010.
- [8] J. Uzan, "Characterization of granular material," *Transportation Research Record*, vol. 1022, pp. 52–59, 1985.
- [9] F. M. Arain and L. S. Pheng, "The potential effects of variation orders on institutional building buildings projects," *Facilities*, vol. 23, pp. 496–510, 2006.
- [10] S. Al-Jishi and H. Al, "Marzoug change orders in construction projects in Saudi-Arabia," in *Proceedings of the Construction Engineering Management Department*, Saudi-Arabia, January 2008.
- [11] D. Olsen, R. Killingsworth, and B. P., "Change order causation; who is the guilty party," in *Proceedings of the 48th Annual International Conference Proceedings of ASC*, pp. 1–9, Birmingham, U.K, April 2012.
- [12] C. Chen, *A Proactive Approach for Change Management and Control on Construction Projects*, University of California, Berkeley, 2015.
- [13] N. Ruben, *An Analysis of the Impact of Variation Orders on Project Performance*, Cape Peninsula university of technology, South Africa, 2008.
- [14] L. O. Oyewobi, "analysis of causes and impact of variation order on educational building projects," *Educ. Build. Proj.* vol. 14, no. 2, 2015.
- [15] A. Alaryan, E. Beltagi, A. Elshahat, and M. D., "Causes and effects of change orders on construction projects in Kuwait," *International Journal of Engineering Research in Africa*, vol. 4, pp. 1–8, 2014.
- [16] H. A. S. Mohammed and E. Elshaikh, "Factors causing variation orders in building projects in khartoum state-Sudan," *IJESRT International. Journal. Engineering. Science. Research. Technology.* vol. 6, 2017.
- [17] R. Karthick, B. Malathi, and U. Gunasekaran, "Study on change order impact on project lifecycle," *International*

- Journal of Engineering Research and Technology*, vol. 4, pp. 691–695, 2015.
- [18] O. Sunday, “Impact of variation orders on public construction projects,” in *proceedings of the Assoc. Res. Constr. Manag.*, pp. 101–110, Leeds, U.K, September 2010.
- [19] A. Al-Dubaisi, *Change Orders in Construction Projects in Saudi Arabia*, king fahd university of petroleum & minerals, Dhahran, Saudi Arabia, 2000.
- [20] S. A. Assaf and S. Al Hejji, “Causes of delay in large construction projects,” *International Journal of Project Management*, vol. 24, no. 4, pp. 349–357, 2006.
- [21] N. Braimah, “Construction delay analysis techniques – a review of application issues and improvement needs,” *Buildings*, vol. 3, no. 3, pp. 506–531, 2013.
- [22] M. Parchamijalal and P. Shahsavand, “The decision matrix approach to dealing with delays in construction projects,” in *Proceedings of the International Conference on Management and Dynamic Economics*, Iran, May, 2016.
- [23] J. B. Yang and C. K. Kao, “Critical path effect based delay analysis method for construction projects,” *International Journal of Project Management*, vol. 30, no. 3, pp. 385–397, 2012.
- [24] M. Parchamijalal, M. Golabchi, and E. Yusefi, “Analysing windows- based Delay analysis methods in easy plan program and offering a framework in selecting the best Delay analysis method,” *Sharif Journal Civil Engineering*, vol. 31, no. 3, pp. 41–49, 2015.
- [25] M. Parchamijalal, P. Shahsavand, and A. Marefat, “Examination and Classification of the Causes of Creating Delays in Construction Projects in Iran and Comparative Analysis Techniques Delay with SCL Protocol,” in *Proceedings of the 11th International Conference of Project Management*, Tehran, February, 2015.
- [26] I. Rashid, M. Elmikawi, and A. Saleh, “The impact of change orders on construction projects sports facilities case study,” *Journal of American Science*, vol. 8, no. No. 8, pp. 628–631, 2012.
- [27] N. T. I. Homaid, A. I. Eldosouky, and M. A. Al-Ghamdi, “Change orders in Saudi linear construction projects,” *Emirates Journal for Engineering Research*, vol. 16, no. 1, pp. 33–42, 2011.
- [28] A. Alaryan, E. Beltagi, A. Elshahat, and M. Dawood, “Causes and effects of change orders on construction projects in Kuwait,” *International Journal of Engineering Research in Africa*, vol. 4, no. 7, pp. 1–8, 2014.
- [29] F. manzoor, “A rain & low sui Pheng developers views of potential causes of variation orders for institutional buildings in Singapore,” *Architectural Science Review*, vol. 1, pp. 59–74, 2006.