Research Article

Ameer A. Alraie, Asaad M. Ali Kadhum and Rana Shabbar*

Causes of change orders in the cycle of construction project: A case study in Al-Najaf province

https://doi.org/10.1515/eng-2022-0340
received March 16, 2022; accepted June 06, 2022

Abstract: In construction projects, the nature of the construction process is complicated, and many factors and variables have a significant role at any stage of the project. Thus, when change orders (COs) occur, the project's function is strongly affected. This study aims at identifying and evaluating the causes of COs in Al-Najaf province projects based on project cycle (stages), to initiate proactive measures to reduce changes during the construction process. This research reviews the previous literature to identify factors causing the COs to develop a categorized questionnaire based on project cycle/stages. Data were collected through field surveys by completing 45 questionnaires during the Autumn of 2018. Analysis results indicated that the COs in construction sites were the result of 24.10% planning, 24.70% design, 11.30% bidding, 36.20% implementation, and 3.70% handover. However, top-ranking causative factors show that the unavailability of project materials in the market is 2.60%, the economic situation of the country and the lack of financial returns is 2.55%, owner capacity in cost estimation is 2.35%, obstruction and delay in giving responses and approvals is 2.30%, indirect cost is 2.29%, and the contractor's experience or technical competence which is not compatible with the project is 2.29%. The top-ranking factors which belonged to the design stage were implementation, planning, design, and bidding stages. The results revealed that the validity of the proposed methodology compared to previous studies and recommendations for further studies was indicated. These outcomes can assist the construction engineers and contractors to enhance the effective change management process and could initiate further research in this field.

Keywords: change orders, project stages, causes, Al-Najaf province

*** Corresponding author: Rana Shabbar,** Structures and Water Resources Department, Faculty of Engineering, University of Kufa, Al Najaf City, Iraq, e-mail: rana.shubber@uokufa.edu.iq
Ameer A. Alraie: Structures and Water Resources Department, Faculty of Engineering, University of Kufa, Al Najaf City, Iraq, e-mail: ameer.alraie@uokufa.edu.iq
Asaad M. Ali Kadhum: Department of Architecture, Faculty of Engineering, University of Kufa, Al Najaf City, Iraq, e-mail: asaadm.ali@uokufa.edu.iq

1 Introduction

Construction project includes different stages starting from planning, design, drawing, estimation cost, tender and bidding, implementation, operation, and maintenance. Through these phases, different decisions should be taken based on assumptions, incomplete information, and construction professionals' experiences. In any construction project, the term "change" refers to a set of instructions that allows modifications, additions, and contract agreement deletions as an expression of the size and scope of work or nature of the task to be carried out. Thus, causes of change in the projects' schedule may potentially boost their cost. Change management is not fully understood or well applied in the construction industry [1,2]. The expression of a change order (CO) is defined as an addition or a decrease in work, which can be created concerning the original scope of work of a contract, and it is a written order signed by the owner to the contractor. It is issued during the implementation stage which could lead to changes in contract amount or completion date. CO in construction is considered to be one of the extremely controversial challenges that must be handled and is difficult to be resolved by the project management team [3,4]. Regardless of its causes, CO often causes disputes and dissatisfactions among the partners, project delays, and is difficult to manage due to additional cost [5].

There are many causes for the issuance of COs in major facility's construction contracts which could be a result of further owner's requirements. Also, it can be due to non-availability or slow delivery of required materials [6]. In addition, due to the correction of the contract document errors and oversights. Characterizing the causes of COs is an important matter to avert potential changes in future projects and/or minimize their effects [7,8]. A few research studies were established on change management in the construction project, especially on the causes of the COs but did not relate them to the construction stages [9–11] and hence this gap is considered a problem to be addressed by the current work. Accordingly, the main objective of the research is to identify the main causes of COs in the construction sector, which are related to construction stages in Al-Najaf province. Furthermore, the causes were classified by stages and ranked according to their impact, then investigated into the potential solutions and recommendations to minimize the inverse COs' effects on the construction projects.

2 Literature review

Several studies have attempted to investigate the impact of COs on construction projects. Alaryan et al. [12] examined the COs in public and private construction projects in Kuwait. The results of a questionnaire survey indicated that the most responsible factor causing changes was plans by the owner. Assbeihat and Sweis [5] studied the causes, effects, benefits, and remedies of COs on public construction projects. The main factors involving COs in projects were identified and classified according to Darwin's open conversion system. They realized that the main causes are those that are related to the client and the lack of national information and database.

Hanif et al. [13] investigated the causes and impacts of variation orders (VOs) in projects in Pakistan using three case studies. The result revealed that the errors and destruction in design, changes in scope and design were the most contributing factors to VOs in hydropower projects and caused time and cost overruns. Khahro et al. [2] revised the influence of COs on project duration. The relative importance weight method was utilized to analyze the main factors. Financial problems of owners and contractors, inadequate drawings, details and design, weathering conditions, changes in project specification, and conflicts in contract documents were detected as the fundamental factors, which caused COs and consequently affect project duration. However, Senouci et al. [8] identified the main causes/factors that cause COs in Qatari construction projects. In addition, they quantified that the cost exceeds the impact of these COs on the construction projects. Statistical methods were used to analyze the collected data such as Pearson correlation and analysis of variance. Regression analysis models were also used to predict CO cost (exceeded and estimate the project size over contract value).

Ibrahim et al. [3] studied the causes of the CO and its impact on the projects. Data mining techniques were used to analyze the causes. It is observed that COs have a significant impact on the cost that should be minimized. The CO was analyzed using the Adda Boost technique and the results were matched with an accuracy of about 95%. Varghese and Xavier [14] reported the identification and assessment of the causes and effects of COs in the construction site, which involved data collection by utilizing questionnaires among the contributors of these changes, which was analyzed using the Relative Importance Index method. Khalifa and Mahamid [7] clarified the main causes of the construction COs in Saudi Arabia, studied their effects on the project, and suggested solutions to decrease the related problems. They demonstrated that the four main causes of COs from the contractors and consultants were the design's errors and omissions, the owner's additional works and financial difficulties, and the lack of coordination and defective workmanship. However, defective workmanship was observed for contractors and differing site conditions for consultants. Mohammad and Hamzah [4] reviewed the causes of order in construction industry projects in Malaysia. The wide literature on different CO causes in the construction industry can assist in understanding their impact on the time, quality performance, and cost of the construction projects. Corresponding to the previous studies, this research aims to know the main reasons that lead to the issue of COs based on stages of construction projects in the Najaf Governorate.

3 Methodology

The methodology of this study consists of the following steps: Several factors causing COs were reviewed in addition to the literature review. This research reviews traditional facilities as well as many types of facilities such as water, wastewater [15], roads and highways [16], renovation [17], and infrastructure projects [11]. Accordingly, a review of previous studies was carried out to obtain the basic variables/factors which are required to create the questionnaire. Then, questionnaires were distributed to two groups which represented the main factors of the construction industry in Al-Najaf province: the first was the public sector which is represented by the Najaf province planning department (7), reconstruction committee and consulting of the Al-ataba Al-alawia (8), maqam Muslim Bin Aqeel consultation office (5), and Kufa cement factory (3). The second was the private sector represented by civil engineers (4) and consultants (10). Data collected from the questionnaires were analyzed by using the SPSS program. Then it was arranged according to its importance and impact percentage. Then, the main reasons for COs in construction projects were identified, and recommendations were taken based on the extracted result. The research methodology of this study is indicated in Figure 1.

3.1 Process of CO

The CO process assists to control the cost and schedule of the major projects which require a higher payment amount in its absence to compensate the contractor through negotiations for assuming the responsibility of addressing unanticipated work requirements. CO execution induces risk to construction contracts due to the lack of competitiveness since the owner usually considers only the pricing and staffing offered by the contractor (a subcontractor) [7]. In most contracts, an engineer (the owner's representative) is responsible for giving the order to change the work. Other contracts give the owner the right to be a party to adopting a CO. Generally, the engineer is responsible for issuing COs, whereas the technical staff is responsible for contract management issues that COs had on pricing and time. Figure 2 illustrates the flow chart of the CO process.

4 Questionnaire design

A questionnaire consisting of two main parts was developed; first part was related to the general information of the respondents such as the type of the sector they work in, the specialization of the entity to which they belong, years of experience, exact specialization, and job. However, second part included the reasons for the COs, within AL-Najaf construction projects during 2016, 2017, and 2018. The chosen timeframe is considered the basis for diagnosing problems due to the economic crisis that started in 2014 when all public funding for construction projects was suspended. A review of previous studies was prepared to obtain the basic variables/factors which are required to create the questionnaire. Table 1 represents the number of main COs caused by previous studies.

According to the previous studies as mentioned in Table 1, the second part was divided into five sections according to the 50 causes (factors) of COs with project cycle (stages) namely planning, design, bidding, implementation, and handover. The ***planning*** stage consists of 12 factors such as lack of study, owner capacity in cost estimation, and security considerations. However, the ***design*** factors were 12 factors which included coordination, conflict in graphics and specification, and groundwater level. However, the ***bidding*** stage has six factors, for example, lack of contract arrangement, unclear instruction, and site conditions that vary with a contract. The ***implementation*** stage includes 18 factors such as technical change, supervision failure, and change/delay in the payment system, whereas the ***handover*** stage has two factors (fire/flood and lack of experience).

5 Data collection

Data were gathered through a questionnaire distributed to some professionals involved in the construction industry. Furthermore, questions about their experience in the construction project and their opinions about COs were surveyed. Accordingly, the data were collected using 50 questionnaires that were distributed to professionals

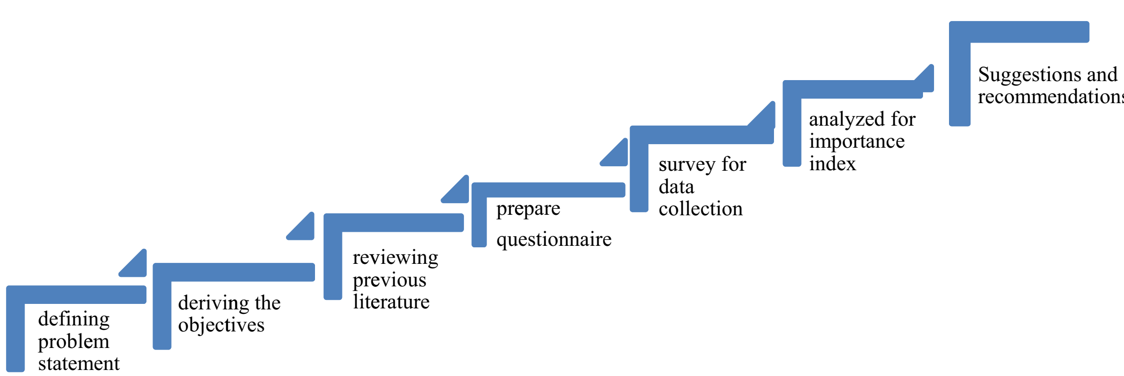

Figure 1: Research methodology.

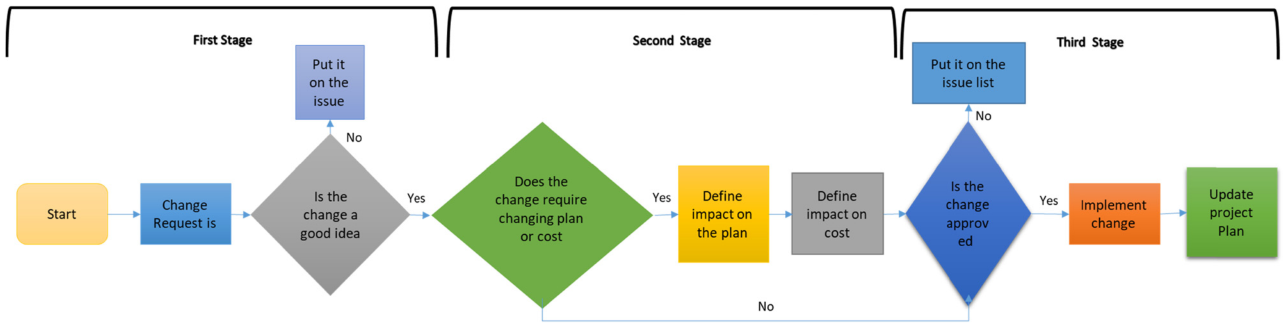

Figure 2: Flow chart of the CO process.

Table 1: Number of main COs caused in previous studies

No.	No. of factors	References	Notes
1	30	[5]	According to labor, materials, contractor, owner, consultant, and regulations
2	36	[1]	Overall review of causes
3	20	[12]	Overall review of causes
4	21	[8]	Project items' costs
5	21	[7]	Overall review of causes
6	18	[4]	Review VO causes
7	10	[3]	Parties, resources, and regulations

involved in the project construction industry. Five questionnaires were cancelled due to miss answers; therefore, the accepted forms were 45. The field survey was conducted during the period from October 2018 to March 2019. Furthermore, the list of the identified causes of a CO in construction projects was presented to provide a weight for each factor according to a five-point scale. The scale rate was classified as very low, low, medium, high, and very high as indicated in Table 2.

The next step includes analysis of the data by encoding the respondent's data by converting the answers into numbers or letters that are easy to deal with on the computer. The data were analyzed using the Excel program and factors were evaluated and ranked using the mean impact index for the list of causes. Then the results were discussed, and the recommendations were provided. To test the stability of the questionnaire, the α coefficient ranges between 0 and 1 (Cronbach's α = 0.88), which was calculated and was 0.97, where N is 50, which indicated the availability of a high degree of questionnaire stability. The data were tested whether the distribution was normal or not using the SPSS V.22 program.

The hypotheses of the samples were tested, and the results were significantly greater than 0.05. The correlation coefficient r was calculated to obtain the coefficient of linear correlation and strength of the correlation and to measure the degree of relationship between these variables using Pearson correlation. Because the data have a normal distribution using the sample size is 45, levels of significance (Sig) for all the variables and r value revealed that there is a positive direct correlation between these variables. This indicates that the results of the field survey were close to the questionnaire data which support the validity of the results. The results for first part of the questionnaire containing the demographic analysis of respondents are presented in Figure 3, which presents the demographics.

Figure 3(a) shows the scope of work, which had the greatest percentage for contractors which was 33.33% (15 people), whereas Figure 3(b) reveals the work specialization which showed that the majority of those covered in the survey were civil engineers, which was 31% (14 people). Figure 3(c) specifies the years of experience showing that 25 of those who filled out the questionnaire

Table 2: Weighted value for importance degree in sample responses

Sequence	Evaluation degree in sample responses	Period or domain
1	Very low	0 to <20
2	Low	20 to <40
3	Medium	40 to <60
4	High	60 to <80
5	Very high	80–100

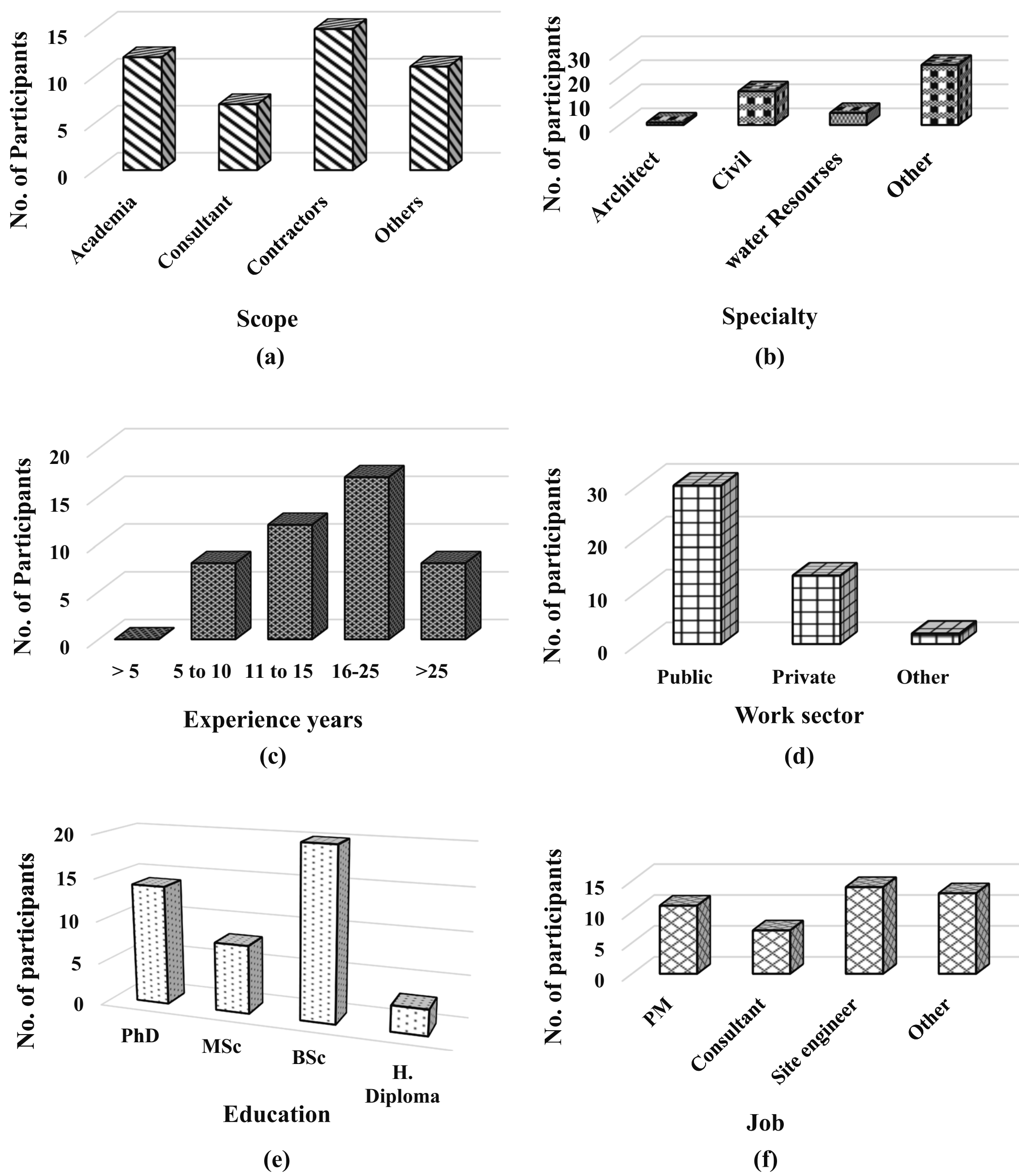

Figure 3: Stakeholders' demographic analysis: (a) scope of work, (b) work specialization, (c) years of experience, (d) sector of work, (e) education degree, and (f) job title.

had more than 15 years of experience, which was 56%. Furthermore, Figure 3(d) indicates the work sector where most of those who worked in the public sector and their number was 30 people with 67%. However, Figure 3(e) reveals the educational level where the analysis showed that 14 people had a PhD which was 31%. Figure 3(f) represents the job title where the site engineer was the most responding who filled out the forms and it was 24.44% (11 people) which gave a realistic indicator of sample representation.

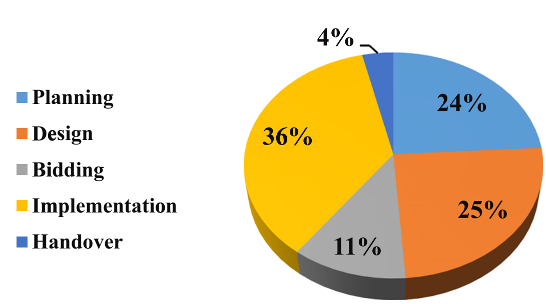

Figure 4: Standard weight% for each stage.

Table 3: Global factors are ranked according to their impact and stage

Rank	Sign	Factor	Impact%	Stage
1	F_{22}	Unavailability of project materials in the market	2.60	2
2	F_{28}	The economic situation of the country and the lack of financial returns	2.55	4
3	F_{12}	Owner capacity in cost estimation	2.35	1
4	F_{21}	Obstruction and delay in giving responses, approvals, and sharing the work site or part of it	2.30	1
5	F_{46}	Indirect costs associated with claims, warranties and warranty equipment maintenance and equipment depreciation, staff-related insurances, taxes, and compensations	2.29	2
6	F_{39}	The contractor's experience or technical competence is not compatible with the project	2.29	3
7	F_5	Lack of permanent coordination between the competent authorities and the project supervisors	2.26	2
8	F_{27}	Conflicts in graphics, specifications, and site terms	2.26	2
9	F_{29}	The need to change the technology used in the project	2.21	4
10	F_8	Lack of planning, research, and study	2.18	1
11	F_{16}	Failure of the Implementation Supervision Department to carry out its duties as it should	2.18	4
12	F_{19}	A change in the sequence or timing of certain works	2.18	4
13	F_{26}	Shortage of project financing	2.18	4
14	F_{23}	Delay in disbursing the monthly statements	2.15	4
15	F_{11}	The project staff is insufficient	2.10	4
16	F_{38}	Short time limit for implementation	2.10	4
17	F_{47}	Change in the payment system or delay in payments	2.10	4
18	F_{34}	Not coordinating project schedules	2.09	2
19	F_{18}	Lack of good arrangement in terms of the contract related to implementation	2.09	3
20	F_{43}	Giving the contractor an opportunity for the owner to see the conditions of the site before making changes	2.09	3
21	F_1	A difference in site conditions resulting from the presence of natural or physical obstacles that are not visible and cannot be expected	2.07	1
22	F_{42}	Direct costs associated with claim owner cost of materials, shipping, and storage site supervision staff safety rates	2.04	2
23	F_{17}	Security considerations	1.99	1
24	F_{31}	Weakness of the level of some engineering offices	1.99	1
25	F_{14}	The right of the owner to make changes before or during the implementation period	1.99	4
26	F_{36}	Failure of the owner to provide the required supplies	1.99	4
27	F_{45}	Claims related to the quality and guarantee of implementation	1.99	4
28	F_{35}	Inaccurate perception of the owner about his requirements and goals	1.96	1
29	F_{15}	The failure of the owner to fulfill his contractual obligations in terms of cooperating with the contractor and facilitating his task	1.96	4
30	F	The effect of the ground water level	1.95	2
31	F_{30}	Accuracy of feasibility study	1.95	2
32	F_3	Lack of experience, team efficiency, and spirit of cooperation	1.93	5
33	F_{13}	Review and update the general conditions according to developments	1.93	1
34	F_{32}	Lack of engineering staff for the public sector	1.90	2
35	F_7	Failure to provide the contractor with all information about the project	1.90	3
36	F_9	Political factor	1.88	1
37	F_{24}	Additional requirements to the terms of the site	1.88	1
38	F_{44}	The presence of the foundations of old facilities or tanks	1.88	1
39	F_{40}	Site conditions are visible physical conditions	1.84	2
40	F_2	Additional works and modifications during implementation	1.79	4
41	F_{49}	Lack of staff experience to manage different design options	1.79	2
42	F_{48}	Compulsive factors fire flood	1.77	5
43	F_3	Owners have no previous experience	1.76	4
44	F_{41}	Defects in project equipment	1.76	4
45	F_6	Giving unclear instructions to the contractor which is difficult to implement	1.76	3
46	F_{37}	Failure to ensure the integrity of designs and project documents before implementation in the project	1.73	2
47	F_{10}	Changes due to regulations and building codes	1.71	1
48	F_4	Cancellation of an essential part of the project, which affects the price of the contractor	1.65	4
49	F_{25}	Bad relations between workers	1.57	4
50	F_{50}	Site conditions faced by the contractor vary as found in the bid	1.17	3
	Total		**100%**	

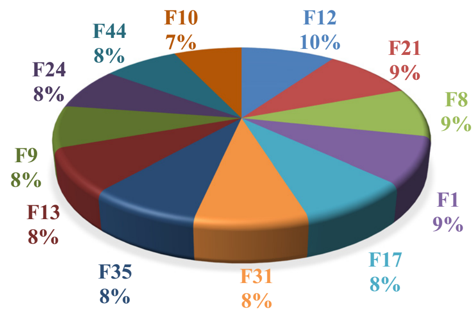

Figure 5: Local impact of factors in the planning stage.

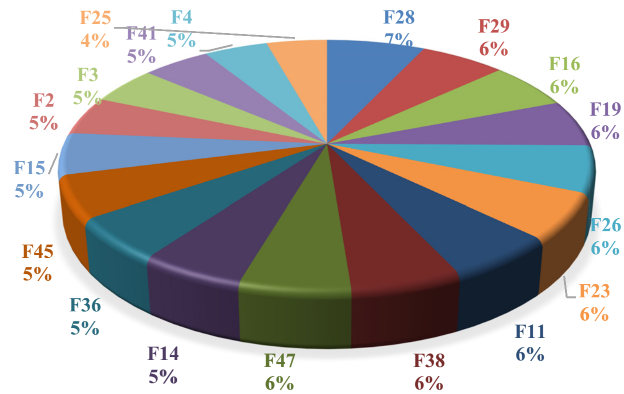

Figure 8: Local impact of factors in the implementation stage.

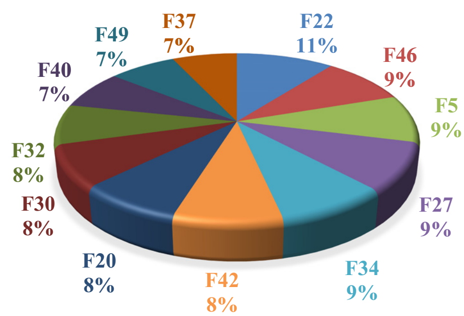

Figure 6: Local impact of factors in the design stage.

6 Results and discussion

The analysis of the questionnaire (part two) yielded the standard weights and percentages for each of the five stages included in the cycle. Accordingly, it was evaluated that the accumulated weight for planning stage factors was 24%, followed by 25% for the design stage, 11.30% for the bid and contracting stage, 36% for the implementation stage, and 4% for handover (delivery) stage, as illustrated in Figure 4.

The global ranking of these factors according to their impact from greatest to the lowest along with their corresponding project stages is indicated in Table 3.

Next, the results are presented according to each stage and are termed "local impact" in which the factors in each stage had a percentage based on their contribution to the total stage weight. The analysis results of the total standard weight according to the five stages revealed that the total global impact of the factors in the ***planning stage*** was 24%. This percentage is turned into 100% and subdivided according to factors' participation in each stage. The greatest local impact result was for F_{12} which was 10%, followed by F_1, F_8, and F_{21} which was 9%. However, F_9, F_{13}, F_{17}, F_{24}, F_{31}, and F_{35} was 8% and the lowest value was 7% for F_{10} (Figure 5).

The analysis results indicate that the main factors in the ***design stage*** were 25% as revealed in Figure 6. The highest local impact value was for F_{22}, which was 11%. This percentage is turned into 100% and subdivided according to factors' participation in each stage. Then it declined to 9% for F_5, F_{27}, F_{34}, and F_{46}, respectively. However, it was 8% for F_{20}, F_{30}, F_{32}, and F_{42}. The lowest value was 7% for F_{37}, F_{40}, and F_{49}.

In the third stage, the analysis results indicate that the main factors in the ***bidding stage*** were 11% as presented in Figure 7. This percentage is turned into 100% and subdivided according to factors' participation in each stage. The results for local impact were close, which were 20% for F_{43}, 18% for F_{18}, 17% for F_7, 16% for F_6, and 10% for F_{50}.

However, the results of the main factors in the ***implementation stage*** were 36% as displayed in Figure 8.

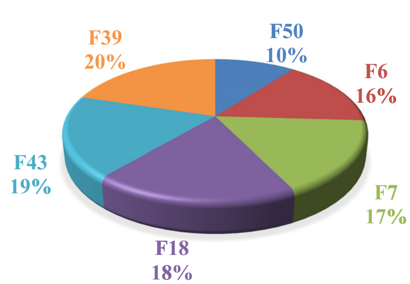

Figure 7: Local impact of factors in the bidding stage.

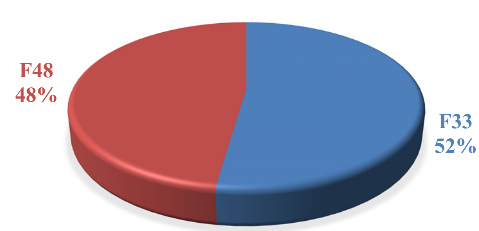

Figure 9: Local impact of factors in the handover stage.

Table 4: Comparison of current research methodology results with previous studies

Stage	Study factors	Research factors (F_n)	References
Planning	Coordination	9,17,21,31	Alaryan et al. [12]
	Technical	1,8,10,12,13,24,35,44	Staiti et al. [1]
Design	Owner requirements	20,22,30,40,42	Staiti et al. [1]
	Design details	46	Senouci et al. [8]
	Coordination	5,34	Alarayn et al. [12]
	Codes and regulations	37	Khalifa and Mahamid [7]
	Errors	27	Alaryan et al.[12]
	Consultant	32,49	Alaryan et al. [12]
Bidding	Contractor	39	Ibrahim Naji et al. [3]
	Scope of work	18,43,50	Alaryan et al. [12]
	Documentations	6,7	Varghese et al. [14]
Implementation	Owner's changes	3	Alaryan et al. [12]
	Shortage in manpower/materials/equipment	11,36,41,15	Ibrahim Naji et al. [3]
	Lack of comm./co-ordination/experience	2,4,14,19	Staiti et al. [1]
	Changes in plan/materials/tech	29,38,45,25	Senouci et al. [8]
	Financial challenges	26,28,47	Khalifa and Mahamid [7]
	Consultant capacity	16,3,23	Senouci et al. [8]

This percentage is turned into 100% and subdivided according to factors' participation in each stage. The minimum result for local impact was for F_{25}, which was 4%, then it increased to 5% for F_2, F_3, F, F_{14}, F_{15}, F_{36}, F_{41}, and F_{45}. Followed by 6% for F_{11}, F_{16}, F_{19}, F_{23}, F_{26}, F_{29}, F_{38}, and F_{47}. However, the maximum local impact value was for F_{28}, which was 7%.

Furthermore, the analysis results in the ***handover stage*** were 4%. This percentage is turned into 100% and subdivided according to factors' participation in each stage as follows, as illustrated in Figure 9.

Then the result of this research was compared to other related research and the general comparison is summarized in Table 4 about the stages of the process.

Although this research used a different methodology like using project stages rather than parties involved in the process (owner, consultant, and contractor), the comparison showed that the factor selected for each stage covered the list of causes presented by other studies using parties involved in methodology. This indicates that the proposed methodology could be used as an alternative method to investigate the causes of the CO process in a comprehensive and reliable approach.

Therefore, in this study, an alternative definition to the term "CO" based on projects' stages was suggested as "a deviation from a project planned activities built on various causes related to project stages," whereas the advantages of this methodology can be summarized as follows:

A. Identification of the gaps in capacity in each stage to address and improve the process.
B. This methodology can be utilized to predict how potential changes are likely to occur during the project cycle. The classification of the probability of changes could range from less than 5% (no changes or no cost/plan impact) to minor up to 20% (no/minor change needed), moderate range between 21 and 50% (consider no-cost changes or period extension) and major more than 50% (investigated changes in time/cost).
C. Adaptation of a proper method to generate a mathematical model that can be utilized by software development.

A mathematical model can be developed according to the currently proposed methodology, which can be programmed interactively by gathering project data from users through a set of questions with a score ranging from 0 to 100. Questions can be based on the 50 causes listed in this research according to each stage of the project starting from the planning stage to the handover stage. The results determined how potential the occurrence of CO, which provides mathematical evidence about classification and where it should be improved.

7 Conclusions

In this research, the COs in construction projects in Najaf province were studied based on a field survey conducted through a structured questionnaire distributed to owners, consultants, and contractors of the construction projects. The results revealed that the implementation stage had the greatest impact on the CO, followed by design, planning, bidding, and handover. The high score for the implementation stage can be attributed to a large number of factors involved and the number of parties contributing to the process, and the highest expenditure rates compared to other stages.

The hypothesis test was carried out to confirm the agreement between the consultants, contractors, and owners about the causes of COs based on the project cycle (stages). It was concluded that the factors which had the main impact on Al-Najaf province construction projects were unavailability of the project materials in the market; the economic situation of the country; lack of financial returns; owner capacity in cost estimation; obstruction and delay in specific responses; approve and share whole/or part of site work; indirect costs associated with claims; warranties of equipment maintenance; and equipment depreciation which are related to insurances, taxes, and compensations.

7.1 Recommendations

The following corrective/reformatory steps are recommended to be adhered to improve the management of construction projects in Iraq:

1. A specialized national technical unit should be established to study and evaluate the construction practices in Iraq to create a construction procedure manual and continue its implementation.
2. For any project design, a standard manual should be developed to control all stages (steps) including feasibility study, design, bid evaluations, and project awards that should be implemented by a specialized governmental unit.
3. A national database system related to underground services, soil, and weather conditions should be developed and maintained as it is beneficial and available to all concerned parties.
4. The client should prepare a brief document about all requirements before entering the design stage, which can be prepared either by carrying out a feasibility study or questionnaire distributed to the project users. Also, conducting sufficient deliberation regarding the project's impact on existing service networks for instance electricity, water, and sanitation.
5. Further studies should be prepared regarding the impact of the COVID pandemic on the COs through the project stages.
6. New software can be created to assess the probability of the COs based on data input at the early stages of the project.

Conflict of interest: Authors state no conflict of interest.

References

[1] Staiti M, Othman M, Jaaron A. Impact of change orders in construction sector in the West Bank. International Conference on Industrial Engineering and Operations Management; 2016. p. 1690–8.
[2] Khahro S, et al. Effect of change orders on project duration. Int J Civ Eng Technol. 2017;8:484–90.
[3] Ibrahim Naji H, Amer W, Maula B. Change orders in Iraqi construction projects. Open Civ Eng J. 2018;12:458–67.
[4] Mohammad N, Hamzah Z. A review of causes of variation order in the construction of terrace housing projects in Malaysia. MATEC Web Conf. 2019;277:03013.
[5] Assbeihat JM, Sweis G. Factors affecting change orders in public construction projects. Int J Appl Sci Eng. 2015;5(6):56–63.
[6] Saif F. Construction project and change order management: contemporary affirmation of the recent literature and future research directions; 2013.
[7] Khalifa W, Mahamid I. Causes of change orders in construction projects. engineering. Technol Appl Sci Res. 2019;9:4956–61.
[8] Senouci A, Alsarraj A, Gunduz M, Eldin N. Analysis of change orders in Qatari construction projects. Int J Constr Manag. 2017;17:280–92.
[9] Shafaat A, Mahfouz T. Can contractors predict change orders. Invest Hist Alleg. 2016;487–96.
[10] Shalaby Y, Khalafallah A. Change order disputes: technical causes and negative effects in kuwait, in construction research congress. 2018;2018:315–25.
[11] Hansen S, Rostiyanti SF, Rif'at A. Causes, effects, and mitigations framework of contract change orders: lessons learned from GBK aquatic stadium project. J Leg Aff Dispute Resolut Eng Constr. 2020;12(1):05019008.
[12] Alaryan A, Emadelbeltagi, Elshahat A, Dawood M. Causes and effects of change orders on construction projects in Kuwait. Int J Eng Res Appl. 2014;4(7):1–8.
[13] Hanif H, Khurshid MB, Lindhard SM, Aslam Z. Impact of variation orders on time and cost in mega hydropower projects of Pakistan. J Constr Dev Ctries. 2016;21:37–53.
[14] Varghese A, Xavier A. Study on causes and effects of change orders in construction sites. Int J Sci Eng Res. 2018;9(4):4.
[15] Fathi M, Shrestha PP, Shakya B. Change orders and schedule performance of design-build infrastructure projects: comparison between highway and water and wastewater projects. J Leg Aff Dispute Resolut Eng Constr. 2020;12(1):04519043.
[16] Assaad RH, Ahmed MO, El-adaway IH, Shrestha PP. Management of change orders in infrastructure transportation projects. practice periodical on structural design and construction. 2022;27(1):05021006.
[17] Kim JJ, Miller JA, Kim S. Cost impacts of change orders due to unforeseen existing conditions in building renovation projects. J Constr Eng Manag. 2020;146(8):04020094.