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Cost Risk Management for Variation Orders in Road Projects in Iraq

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K E Y W O R D S

Change order, Variation order, Cost risk management, Road projects.

A B S T R A C T

This paper aims to develop appropriate solutions for each of the causes for the change orders, which help to manage the cost risk in road projects in Iraq. The literature was reviewed in detail, and the objectives were implemented by using a questionnaire that was distributed to specialists in the public sector to survey all possible causes for exceeding the cost of road projects. As a result, 35 causes were identified for a large number of change orders in road projects and their classification into four axes: design, implementation, financial, and other causes. The results of the questionnaire were analyzed using the relative importance index (RII). As a result, the main causes of the change orders were the variations in design and the quantities of work. The main effect was found to be an increase in the cost of the project. Finally, solutions were collected for each of the factors causing the change order through personal interviews with professionals and consultants.

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1. Introduction

Change orders in construction are the variations that happen in different phases of the project because of different factors causing different impacts in the construction up to the failure of the project often. In Iraq, almost all projects have delays in completion and cost impacts because of the change orders, which are not well managed. Because of that, this research intends to give the construction industry the change order causes, effects, controls and their impact on the cost to the Iraqi construction industry by taking into consideration the survey questionnaire done with the professionals.

2. Research Objectives

1. Identify the factors, which cause the change orders for road projects.
2. Determination of the change orders effect on the project cost.
3. Determination of the controls for the change orders.

3. Research Methodology

For this research, the following steps were conducted:
a. A literature review was presented to cover the previous studies regarding the change orders in road projects caused cost overruns. Based on this review, different causes that are expected to affect the cost overruns were identified.
b. The causes that contributed to the change orders were identified and these reasons were obtained through previous studies and through personal interviews with professionals who are specialized in project management and placed in a questionnaire. A questionnaire target owners, consultants, supervising engineers and contractors working on the public sector to identify the most critical causes of change orders caused cost overrun in road projects in Iraq.
c. Analyse the causes of change orders using the relative importance index.
d. Develops solutions for the causes and factors that cause the change orders based on a questionnaire.
e. Building a management system to control the change orders.

4. Literature Review

I. Change order definition

Defined the change orders as any event, which results in a modification of the original scope, execution time or cost of work [1]. A change order is a legally binding document used to make changes to the contract [2]. It is a written instrument prepared by the Architect and signed by the owner, contractor, and architect [3].

II. Change order types

Change orders are classified into four main types [4]:
1. Additive changes are changes that are added to the original scope of work.
2. Deductive changes are changes that deleted from the original scope of work.
3. Reworks are changes made due to quality deficiencies.
4. Force Majeure changes are changes made as a result of the weather conditions which can impact the schedule and cost of the project.
5. Two types of change orders exist; normal change orders and emergency change orders [5].

III. Causes of change orders

Classified the causes of change orders into four categories [6], as shown in Figure 1.

IV. Change orders impact on project cost

The cost impact is calculated as the difference between the actual cost and the original budget [7]. One of the models has calculated the cost impact based on the (equation 1) [8].

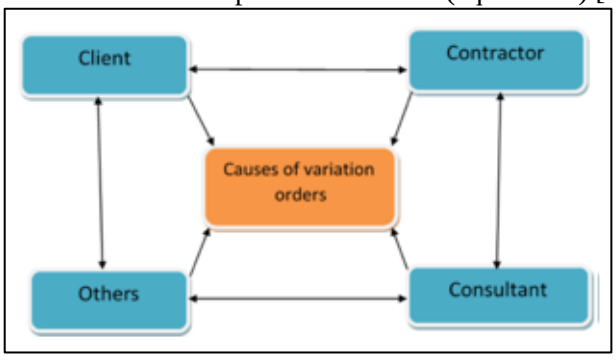

Figure 1: Factors causing variation orders [6]

$Change\ In\ Cost$ (%) = (Final Cost-Original Budget) / (Original Budget) x 100 (1)
Built a model to calculate the impact of changes in cost based on (equation 2) and concluded that only 57% of the changes in the response variable increase the contract price [9].

$\%inc.\ due\ to\ change$= (Cumulative Cost of the Change Order to date) / (Original Cost of the Project) x 100 (2)

In both cases, the calculation of the cost impact is based on the original cost/budget of the project.

5. The Questionnaire Survey

A closed questionnaire form was designed to identify the local causes of change orders based on the previous local and international studies and new issues generated through the dialogue with the respondents. Thirty-five leading causes of change orders were classified into four groups; design-related, implementation-related, financial-related and other factors. These groups were listed in a questionnaire form to obtain the local expert opinions about their applicability in the case study. Table 1 illustrates the questionnaire form used to show the (35) causes of change orders in road projects and their final screening and ranking based on the questionnaire results discussed later. A total of (82) out of (100) distributed questionnaire forms were collected forming a response rate of (82%). The respondents consist of (27) from owner representatives, (8) from consultants, (38) from supervising engineers and (9) contractors.

6. Questionnaire Analysis

The questionnaire form was designed using the 5-point Likert's scale to obtain the answers for each question. The relative importance index (RII) of the various causes of change orders was calculated according to (Ozdemir) [10] who used the relative importance index (RII) method to determine the relative importance of the various causes. The five-point Likert's scale ranged from (1 = not important) to (5 = very highly important) is adopted and transformed to relative importance indices (RII) for each factor in the questionnaire using (equation 3).

$$\mathbf{RII} = \left(\frac{\sum \boldsymbol{W}}{\boldsymbol{A}\times\boldsymbol{N}}\right) \quad (3)$$

Where:
W: The weight given by the respondents and ranges from (1 - 5),
A: the highest weight is given by the respondents (for each factor), and
N: the total number of respondents, which equals to (82).

7. Results of Analysis

According to the ranking of the groups, the factors of each group that contribute to most of the change orders are analyzed below:
1. Design (RII= 0.689): The Design-related causes, which most significant factors are change of design, (RII= 0.817), Inadequate design (RII= 0.768), Error and omissions in design (RII= 0.759), and Poor estimation (RII= 0.749).
2. Implementation (RII= 0.683): The implementation-related causes, which most significant factors were changed in the quantities of the work (RII= 0.810), change in specifications (RII= 0.771), change of design by the consultant (RII= 0.746), and the consultant does not have the ability to give the technical decision (RII= 0.722).
3. Financial (RII= 0.717): The financial-related causes, the most significant factors were the client's financial problem (RII= 0.807), and change in economic conditions (RII= 0.766).Also, others (RII= 0.709): The other causes, most significant factors were delayed in fundamental approvals of materials, machinery and workers (RII= 0.741), unforeseen problems (RII= 0.707).
Table 1 shows the average of the respondents' responses about the extent of influence (no impact, low, medium, high and very high) for each of the causes mentioned. Column (RII) shows the relative importance index for each cause after applying equation (3) and column (Rank) showing the sequence of causes, according to the relative importance, for example, the most important cause is

sequentially 1. Table 2, summarizes the RII for the groups of change orders according to the respondents.

Table 1: The questionnaire form showing respondents' scores and RII

Design-Related Causes		**Impact**					**RII (%)**	**Rank**
		No	**Low**	**Med.**	**High**	**V. high**		
1	Inadequate design	2	7	21	24	28	76.8	5
2	Change in design	1	3	10	42	26	81.7	1
3	Error and omissions in design	0	12	12	39	19	75.9	7
4	Poor estimation	4	2	22	37	17	74.9	8
5	Conflicts between contract documents	2	16	35	21	8	64.1	29
6	Lack of contractor's involvement in design	18	31	17	14	2	48.0	35
7	Non-compliant design with owner's requirement	5	10	30	27	10	66.6	25
8	Design discrepancies	4	9	31	31	7	66.8	22
9	Insufficient details in design drawings	2	14	29	25	12	67.6	19
10	Inadequate project activities	3	16	31	17	15	66.1	27
Implementation -Related Causes		**Impact**					**RII**	**Rank**
		No	**Low**	**Med.**	**High**	**V. high**	**(%)**	
11	Change of materials	3	6	36	28	9	68.3	17
12	Change in the quantities of the work	1	2	14	40	25	81.0	2
13	Insufficient planning by project management	1	11	23	40	7	70.0	14
14	Materials not available	8	12	23	24	15	66.3	26
15	Unforeseen site conditions	3	10	20	34	15	71.7	12
16	Environmental health and safety considerations	3	28	31	15	5	57.8	34
17	Unavailability of skills of the staff	12	7	21	24	18	67.1	20
18	Unavailability of adequate equipment for each project activity	15	11	15	18	23	65.6	28
19	Poor performance of contractors	13	12	14	20	23	66.8	22
20	weather conditions	1	12	56	8	5	61.0	32
21	Purchase of non-conforming materials	2	17	32	24	7	64.1	29
22	Contractor's lack of required data	3	26	30	19	4	58.8	33
23	Consultant's lack of required data	2	10	31	26	13	69.3	16
24	Honest wrong beliefs of consultant	5	10	25	25	17	69.5	15
25	The consultant does not have the ability to give the technical decision	1	8	27	32	14	72.2	11
26	Change in design by the consultant	3	2	26	34	17	74.6	9
27	Change in the specifications	2	4	23	28	25	77.1	4
28	Change of the schedule	2	7	43	20	10	67.1	20
Financial -Related Causes		**Impact**					**RII**	**Rank**
		No	**Low**	**Med.**	**High**	**V. high**	**(%)**	
29	Contractor financial difficulties	12	9	16	29	16	66.8	22
30	Client's financial problem	3	3	11	36	29	80.7	3
31	Change in economic conditions	1	2	24	38	17	76.6	6
32	Contractor's desired profitability	6	12	37	19	8	62.7	31
Others causes		**Impact**					**RII**	**Rank**
		No	**Low**	**Med.**	**High**	**V. high**	**(%)**	
33	Delay in fundamental approvals of materials, machinery and workers	5	8	13	36	20	74.1	10
34	Long lead procurement	2	13	27	31	9	67.8	18
35	Unforeseen Problems	1	6	32	34	9	70.7	13

Table 2: RII for all groups of factors of change orders

The group	RII
Design-Related Causes	68.9%
Implementation -Related Causes	68.3%
Financial -Related Causes	71.7%
Others causes	70.9%

8. Solutions for Each Cause of Change Orders

Solutions were developed for each of the causes of the change orders to minimize or avoid those changes. These solutions were collected through interviews with professional consultants who have experience in road projects. These solutions were then linked to each cause in the questionnaire to find the optimal solution for each cause. The researcher obtained the following results are shown in Table 3.

9. Discussion of Search Results

1. Table 1 and 2 illustrate the analysis of the results of the first questionnaire using the relative importance index, in which the most important causes leading to change orders were identified. Table 1 shows the causes of the most important to the least important. This is one of the objectives of the research.

2. Table 3 shows the analysis of the results of the second questionnaire using the relative importance index and through its results shows that the solutions developed for each cause are objective and realistic solutions, according to the responses of the respondents in the questionnaire and the development of solutions is one of the main objectives of this research.
3. The limits of this study are the work of an administrative system that includes all the causes collected through field research as well as solutions for each cause to be followed to reduce or avoid the occurrence of change orders as much as possible. For example, there is a cause in one of the projects that caused a change order was obtained through field survey more than one solution for this cause then we go to the solution that got the most percentage in the relative importance index and then the least sequentially.

Table 3: Solutions for each of the causes of the change orders

No.	Causes	Solutions	RII	Rank
Design-Related Causes				
1	Inadequate design	1. Preparing designs suitable for the type of establishment, its uses, purpose and the requirements of the beneficiary	0.968	2
		2. Assigning expert designers to suit the type, uses, and requirements of the beneficiary	0.973	1
		3. The design must conform to the function for which it was found and this depends on the design requirements that the consultant determines with the owner before starting the design.	0.963	3
2	Change in design	1. Minimize the design change by checking after the design is completed.	0.886	5
		2. Assignment of engineers with experience in preparing designs	0.995	1
		3. Use of references and approved global standards in the preparation of designs	0.909	4
		4. Involve the owner in the design to comply with its requirements.	0.776	6
		5. Studying the work requirements in all economic and scientific aspects, taking into account future expansion and changes	0.927	3
		6. Selection of accurate consulting offices in the preparation of the bill of quantities	0.941	2
3	Error and omissions in design	1. Take a responsible approach between the designer and the checker to avoid the error and omissions.	0.954	1
		2. Apply a pilot work environment for the project to observe and diagnose the errors that are not noticed by the designer.	0.735	2
4	Poor estimation	1. Take a responsible approach between the estimator and the checker.	0.868	3
		2. Assignment of estimation to experienced Estimators	0.895	2
		3. Update the price list and keep pace with modern skills and advanced software in calculating quantities and pricing.	0.909	1
5	Conflicts between contract documents	1. Review the documents thoroughly, study and review them by experienced consultants before they are attached to the contract and, it is better to depend on standard documents.	0.968	1
6	Lack of contractor's involvement in design	1. It is necessary to involve the contractor in designs.	0.452	3
		2. Preferably, the contractor is the designer, the construction and the consultant.	0.489	2
		3. Contractors or implementing companies with experience in the method of implementation of the work can be consulted by the consultant designer to ensure that all activities of the project are implemented easily and successfully.	0.721	1
7	Non-compliant design with owner's requirement	1. A study should be carried out by the consultant who designed to meet the needs required by the owner for the design required to work, make a list of design requirements, presentation and discussion in detail with the owner and understanding the job desired by the owner to suit the design and make an experimental design for the owner to review and approve before final adoption	0.877	1
		2. The owner submits and presents his requirements in writing to be approved by the owner's consultants.	0.808	2
8	Design discrepancies	1. The selection of companies or offices of consulting designs with experience in the preparation of designs so that no contradiction occurs, for example, the contradiction of architectural designs with structural or mechanical with health, etc.	0.991	1
		2. Complete all tests, investigations, and surveys before starting detailed designs.	0.968	2
9	Insufficient details in design drawings	1. Inform designers of the need to make details of all plans.	0.918	3
		2. Not to approve the designs only after the details	0.954	1
		3. Audit the architectural plans well before they are accepted or referred to the strict design audit offices for the purpose of installing all the details on the drawings before accepting them and approving them in the implementation.	0.936	2
10	Inadequate project activities	1. Checking all the drawings and matching them to find the shortage in the activities	0.932	2
		2. Depend on integrated architectural design in the preparation of service designs (Structural, mechanical, electrical, sanitary)	0.950	1
		3. Design teams worked with all specialties as one team to discover the shortage of activities.	0.909	3
Implementation Causes				
11	Replacement of material	1. Do not replace raw materials for the project unless they are not available or difficult to bring.	0.849	2
		2. Provide the raw materials in the project as well as the stores by the contractor before a period of time to ensure that they are not lost from the local markets or scouring.	0.932	1
12	Change in the quantities of the work	1. Work according to designs.	0.913	4
		2. Check the quantities with the designs before they are certified.	0.963	2
		3. Use the Standard guide in preparing quantities.	0.918	3
		4. Selection of accurate and strict consulting offices in the preparation of quantities	0.973	1
		5. Formation of the measurement teams during the implementation stages	0.772	5
13	Insufficient planning by project management	1. The project manager shall prepare the plans for all phases of the project, according to time schedules and take them on.	0.909	3
		2. Choose an experienced project manager	0.932	1
		3. preparing a workshop and involve all parties and specialties, that contributed to the preparation of the designs, to plan planning stages of the project and coordinate among them to get out of the critical path plan for the project.	0.776	4
		4. Implement the project management professional (PMP) procedures in the project planning and review from time to time, while changing and updating any changes to the project plan.	0.913	2
14	Unavailability of material	1. Preparation of plans for the processing of materials with continued implementation	0.904	2
		2. Stores to assure the availability of materials.	0.868	3
		3. Selecting the designer for locally available materials when preparing Bills, Designs and Specifications	0.909	1
15	Unforeseen site conditions	1. Prepare financial and time plans while taking into account all unexpected conditions.	0.886	4
		2. Prepare plans by experienced people for anticipating circumstances.	0.922	3
		3. Visit the site by the designer to take into consideration all the obstacles in design and implementation.	0.963	1
		4. The contractor shall visit the site prior to the pricing of the offer submitted by him and the owner will clarify all problems and obstacles.	0.963	1
16	Health and safety considerations	1. Add all safety considerations with the designs and oblige the contractor to follow them and will be checked daily before starting work by the site engineer.	0.881	2
		2. Develop an integrated occupational safety program that is checked by external parties.	0.890	1

17	Unavailability of skills for the staff	1. Involve the teams in training courses and workshops for acquiring the required experience, or work with consultants with long and good experience in similar works.	0.795	2
		2. Increase supervision and control of working teams to ensure good execution.	0.845	1
18	Unavailability of adequate equipment for each project activity	1. Prepare plans to use the equipment	0.781	4
		2. Purchase necessary equipment suitable for the works.	0.886	3
		3. Attention to the deterioration and maintenance of equipment	0.900	2
		4. Provide experienced operators.	0.941	1
19	Poor performance of contractors	1. The financial position of the contractor	0.977	1
		2. Similar work.	0.954	3
		3. Selection of contractors or companies contracting strict performance and high efficiency with the need to work a list of contractors and companies to depend on them when the announcement of a tender or the implementation of works within the project	0.963	2
20	Weather conditions	1. Study of climatic conditions to predict the rainfall and temperature during the year, as well as depend on weather applications, which are available and provide a good indicator of the weather and before an acceptable period of time	0.909	1
21	Purchase of non-conforming materials	1. Submitting all the materials involved in the work to the laboratory examination and selection of random samples and sent to the laboratory examination and compliance with the examination reports to ensure that the specification required by the design	0.991	1
		2. Identify the suppliers that are committed to the materials and their specifications.	0.877	2
22	Contractor's lack of required data	1. Provide the contractor with all the required data with the compelling to visit the site and the work of a meeting and call for all contractors willing to work and participate in the tender to ask their questions and answer them in detail.	0.904	2
		2. The tender is not accepted by a contractor who did not receive the documents in full, especially specifications and designs.	0.954	1
23	Consultant's lack of required data	1. Provide the consultant with all the technical and financial priorities of the project and involve him in the design stages.	0.913	2
		2. Choose a consultant with experience and decisiveness.	0.954	1
		3. Work meetings and extensive discussions with the engineers and expert consultants on the project with the consultant to give him the full picture of the reality of the project	0.877	3
		4. Establish a rapid and effective communications and communication plan between all parties of the project, and update the changes and assess the problems so that the consultant can find appropriate solutions.	0.854	4
24	Honest wrong beliefs of consultant	1. Choose an expert consultant on the project.	0.936	2
		2. Inform the Consultant of his responsibility	0.927	3
		3. The consultant should depend on the existing facts and not take the decision according to the belief and expectation as well as conduct all the required examinations and field disclosure by the consultant before he builds his opinion and makes his decision.	0.954	1
25	The consultant does not have the ability to give the technical decision	1. Selection of highly experienced and officially accredited consultants suitable for similar work	0.986	1
		2. Setting rules and conditions for issuing decisions by the consultant and specifying his obligations	0.895	3
		3. Giving the consultant the necessary power to take appropriate decisions and to rule on controversial issues and disputes	0.922	2
26	Change in design by the consultant	1. Involve the consultant in the stages of preparing the designs.	0.890	1
		2. Taking the opinion of the consultant only in case the non-implementation affects the safety of the facility	0.689	3
		3. Reviewing the design with the consultant or presenting the design to another consulting office for the purpose of checking the design and not resorting to changing them during work	0.831	2
27	Change in specifications	1. Adopting acceptable specifications when preparing design and checking them after completion of the design	0.954	1
		2. Agreement on the standard specifications of the project during the stage of preparing the designs and not changing the specification in response to the desires and atmosphere	0.941	2
		3. The specification should be based on the nature of the required standard, with no exaggeration in the addition and increase.	0.932	3
28	Change of schedule	1. To comply with the time schedules established in the work progress schedule and not to exceed them, especially those on the critical path, with sufficient backup time to be exhausted during project implementation without affecting the critical path and during the preparation phase of the work of the project	0.941	1
		2. Prepare accurate schedules by expert engineers.	0.941	1
		3. Periodic review of schedules by the project manager	0.913	3
Financial Causes				
29	Contractor financial difficulties	1. Check the financial position of the contractor.	0.954	1
		2. Claim similar work.	0.950	2
		3. Selection of contractors with strict performance and high efficiency with the need to work a list of contractors and companies to depend on them when the announcement of a tender or the implementation of works within the project	0.918	3
30	Client's financial status	1. Preparing budgets for the project at the design stage to ensure financial allocations	0.895	3
		2. Take measures to provide financial liquidity, such as money transfers or loans from banks.	0.913	2
		3. Allocation of the necessary financial amounts for the project and deposit in bank accounts before the payment due to the contractor is due to a period of time	0.922	1
31	Change in economic conditions	1. Preparation of risk management plans	0.900	1
		2. Expect variation in economic conditions at the design stage	0.712	3
		3. Pricing the contract in a fixed currency (dollar and other) to avoid the mutations that may occur because of the change in economic conditions	0.858	2
32	Contractor's desired profitability	1. Declaration of the total cost of the project when the announcement of the tender to be known to the contractors the total amount allocated for the implementation of the project and therefore not overpriced in the pricing of activities for the purposes of profitability	0.817	1
Others causes				
33	Delay in fundamental approvals of materials, machinery and workers	1. Attention in the issuance of approvals during the design stages	0.826	2
		2. Develop an administrative system, through which the bureaucracy is reduced in official approvals.	0.895	1
34	Long lead procurement	1. Prepare plans to purchase materials to ensure the availability of them during the week.	0.913	1
		2. Assure multiple sources of material purchase	0.726	2
		3. Adopting simplified purchasing methods through supply by means of modern methods such as (online) or purchase from suppliers with advanced and fastest systems in the supply of goods and materials	0.717	3
35	Unforeseen Problems	1. Predict problems and prepare ready solutions for each expected problem.	0.872	2
		2. Make updates in plans under the problems to solve the problem during the implementation phase.	0.881	1

10. Conclusions

As a result of this research, the following conclusions are drawn:

1. From the results of the first and second questionnaires, it can be concluded that the most influential causes for change orders related to the design axis are the change in design and can be minimized or avoided by

assigning experienced engineers in the preparation of designs, the selection of accurate consultancy offices in the preparation of tables of quantities, study the requirements of work in all economic and scientific aspects taking into account the expansion and future changes, the use of references and international standards adopted in the preparation of designs, reduce the design change by verification after completion of the design and involve the owner in the design to comply with its requirements.

2. Also, from the results of the first and second questionnaires, one can deduce that the most influential causes for the change orders related to the axis of implementation are the change in the quantities of work and can be minimized or avoided by choosing careful and careful consultants in the preparation of tables of quantities, checking the tables of quantities with designs before adoption, using of the manual standard in preparing quantities, working according to designs and forming measurement teams during the implementation phases.

3. While, the most influential causes for change orders related to the financial axis are financial problems for the owner and can be minimized or avoided by allocating the necessary funds for the project and depositing in bank accounts before the payment due to the contractor, taking measures to provide financial liquidity, such as transferring money or loans from banks and preparing project budgets at the design phase to ensure the financial allocations.

4. One of the most influential causes for change orders related to other reasons is the delay in the fundamental approvals of materials, machinery, and workers and can be minimized or avoided by issuing approvals at the design stage and the development of an administrative system, through which the routine is reduced by official approvals.

5. The solutions that have been put for each of the causes for the change orders lead to avoid or reduce the occurrence of the change order based on the results of the second questionnaire.

6. Decision-makers can test the solutions proposed by the author in their various projects and determine whether they lead to reasonable results.

List of Abbreviations

Relative Importance Index RII

Variation Order/Change Order VO

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