Journal of Engineering and Architecture
December 2015, Vol. 3, No. 2, pp. 95-104
ISSN: 2334-2986 (Print), 2334-2994 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jea.v3n2a11
URL: http://dx.doi.org/10.15640/jea.v3n2a11

Controlling Of Variation Orders in Highway Projects in Jordan

Majed Msallam[1], Mohammad Abojaradeh[2], Basim Jrew[3] & Inas Zaki[4]

Abstract

Variation orders are the most disruptive and unpleasant events of the projects because of their impacts on cost and completion date of the project. This study is about the variation orders in highway projects that are the most severe problems in the highway projects. Variation order is any modification to the contractual terms of a project by the owner or the owner's representative, it can be a work that is added to or deleted from the original scope of work of a contract, which alters the original contract amount and/or completion date. Change orders are common to most projects, and very common with large projects. This study focuses on the causes of variation orders and their impacts on time and cost. Management system is suggested to control the variation orders of highway projects in Jordon. The data collected from two sources the primary is the survey questionnaire conducted with project managers, contracting, and consulting businesses in highway projects. The secondary is from selected completed highway projects. According to the questionnaire results, the most ten important causes are change of schedule, ambiguous design details, change of plan or scope, conflict between contract documents, lack of coordination, safety considerations, client financial problem, change in design by consultant, socio-cultural factors, and change in government regulations. The main impacts of variation orders are time delays, cost overrun, increase in overhead expenses, turnover of professionals and project team. According to the research findings, a management system has been proposed through the project lifecycle (conceptual, design and construction stages) to control the occurrence of variations and as a result, reducing their impacts. This system was evaluated through another questionnaire and the results showed that the proposed system would be successful tool for controlling variation orders occurrence in the highway projects in Jordan.

Keywords: Variation orders, Jordan, Highway Projects, Time Delays, Management System, and Project Lifecycle.

1. Introduction

Time and budget are two crucial factors which have a tremendous influence on construction projects. This is where the role of project managers comes into play to ensure that the projects are completed in a precise budget and in a timely manner. There are numerous tools that project managers can use in construction projects once a project is started. One of these is the variation orders, which is an important tool used by project personnel to address changes in construction projects after contract award.

[1] Ph.D. Assistant Professor, Faculty of Engineering, Department of Civil Engineering, Isra University, Amman, Jordan. Tel 00962-6-4711710, e-mail: lasam_um@yahoo.com
[2] Ph.D., P.E. Associate Professor
Faculty of Engineering, Department of Civil Engineering, Zarqa University, P.O. Box 2000, Zarqa 13110, Jordan. Tel: 00962-5-3821100, e-mail: abojaradeh@yahoo.com
[3] Ph.D. Professor, Faculty of Engineering, Department of Civil Engineering, Isra University, Amman, Jordan. Tel 00962-6-4711710, e-mail: basim_jrew@yahoo.com
[4] MSc. In Engineering Project Management, Baghdad-Iraq. e-mail: inasszaki@yahoo.com

In other words, variation order is one of the few tools that the project manager contractually has to accommodate for unplanned occurrences once the project is under construction. It is important for a project manager to understand the reasons behind such unexpected variations in a project and has to act accordingly so that the project can be accomplished successfully. This thesis discusses variation orders in highway construction projects in Jordan. The findings of this study would be significant for various practical and theoretical purposes, especially for construction projects related to highway in Jordan.

2. Previous Research

According to Khalid 2012, a MSc. thesis was conducted on controlling of variation orders in water and wastewater projects in Jordan. He stated that the most major causes are: conflict between contact documents, errors and omissions in design , unforeseen problems , differing in site condition, inadequate design , change in specifications, inadequate working drawings, change in design by consultant, ambiguous design details and lack of coordination . And the five major impacts of the variation orders are: completion schedule delay (time overrun), increase in project cost (cost overrun), increase in overhead expenses, additional payments for contractors and procurement delay.

Priyantha et al., (2011) indicated that highways play a critical part within the economic growth of developing countries. Sri Lankan authorities also have recognized such relevance, and it has directed particular focus on construction of new highways. However, highways construction is not an easy job and these jobs in many cases are typified by complexities and dangers creating a variety of issues that need to be dealt with unextreme caution. Variations are one of them, which, are, generally occur due to unclear scopes of work defined at the start. Consequently, his study is undertaken to recognize, causes and effects of variations in highways construction in Sri Lanka. A questionnaire survey was carried out to recognize causes of variations and semi-structured interviews were conducted to get data regarding nature and effects of variations. The results revealed that change in demand increases and mind power were the main reasons for owner while defects and layout changes in BOQ (Bill of Quantities) were the main reasons for consultant originated variations originated variations. Property acquisition and capital organizing problems were identified as variations that are originated by main unforeseeable causes. The study further revealed that omission of any work has a critical effect on the essence of variations. In many scenarios, variations have caused cost overruns with the average increase of 9.9% of the initial contract amount.

Ming Sun (2009) revealed that during many building projects regular changes often lead to cost overruns, time delays, quality defects and other negative impacts. Recently, many researchers worldwide investigated the consequences of job change and more importantly the common causes behind the changes from various views. A significant variety of research papers are published in this area. While most of existing papers presented useful empirical work, very few offered a systematic and comprehensive review. There's additionally a particular amount of confusion within the language used by diverse writers. The aim would be to fill this knowledge gap by: (1) reviewing and synthesizing existing literature on project change causes and effects; (2) developing two taxonomies for change causes and change effects; and (3) illustrating the way the taxonomies may be utilized throughout the project change management procedure.

Arain and Peng (2005),(2006) described the development of the Knowledge Based Decision Support System (KBDSS) for management of variation orders for institutional buildings in Singapore. The KBDSS consists of two primary parts, i.e., a knowledgebase along with a decision support shell for choosing appropriate controls. The database is developed by accumulating information from the source documents of 79 institutional construction projects, questionnaire survey, literature review and in-depth interviews with the professionals who have been involved in these projects. The knowledgebase was developed through first sieving and organization of the info in the database. The decision support shell provided decision support through a structured process consisting of constructing the controls, rating and also the hierarchy between the chief criteria the controls, and assessing the controls for choice through multiple analytical techniques. The KBDSS is effective at exhibiting their pertinent details as well as variations, an assortment of filtered knowledge. The KBDSS is competent to help project managers by supplying timely and accurate information for decision making, along with a system for choosing and assessing the controls for variation orders for institutional buildings.

Sambasivan and Soon (2005) stated that the issue of delays within the construction industry is a world-wide phenomenon, including the construction industry in Malaysia.

The main goal of their study was to identify the delay variables as well as their impact (effect) on job conclusion. Earlier studies either considered the causes or the consequences of project delays, individually. Also showed that it takes an integrated strategy and tried to assess the effect of particular causes on specific effects. A questionnaire survey was conducted to solicit the effects and causes of delay from owners, consultants, and contractors. About 150 respondents participated in the survey. This study identified 10 most significant factors behind delay from a list of 28 different causes and 6 different effects of delay. Ten most significant causes were: (1) contractor's improper preparation, (2) contractor's poor site management, (3) inadequate contractor expertise, (4) inadequate owner's financing and payments for finished work, (5) difficulties with subcontractors, (6) deficit in stuff, (7) labour supply, (8) equipment availability and failure, (9) lack of communication between parties, (10) errors during the building period. The six main effects of delay were: (1) time overrun, (2) cost overrun, (3) disputes, (4) mediation, (5) litigation, (6) complete rejection. This study has also established an empirical relationship between each cause and effect.

P. A. Koushki et al., (2005) studied delays and cost increases in the construction of private residential projects in Kuwait, time-delays and cost-increases associated with the construction of private residential projects in the State of Kuwait are determined. A personal-interview survey of 450 randomly selected private residential project owners and developers in 27 representative districts in metropolitan area. They founded that the three main causes of time-delays included changing orders, owners' financial constraints and owners' lack of experience in the construction business. Regarding cost overruns, the three main causes were identified as contractor-related problems, material-related problems and, again, owners' financial constraints. The minimization of time delays and cost overruns in private residential projects would require: the availability of adequate funds, allocation of sufficient time and money at the design phase, and selection of a competent consultant and a reliable contractor to carry out the work.

3. Research Objectives

The main objectives of this study are;

1. To investigate and identify the root causes behind variation orders on highway related projects in Jordan
2. To examine the various impacts of variation orders occurrences on highway related projects in Jordan
3. To suggest management system to control the variation orders on highway related projects in Jordan and to ensure that projects are completed in a timely manner within the stipulated budget.

4. Data Collection and Analys

The sources of the collected data in this chapter were classified into two parts. The first is the secondary source representing the owner's documents who are the Ministry of Ministry of Public Works and Housing in Jordan. The second part is the primary source which includes data collected from a questionnaire survey carried out with managers of highway projects. The study ends with a demonstration of the findings, which will be used for proposing a management system for controlling variation orders in highway projects; the third objective of this research.

4.1 Existing Highway Project Documents for Variation Orders

Data of variations orders have been collected from real life existed highway projects which is taken from the Ministry of Public Works and Housing in Jordan (MOPWH). The data were analyzed to determine the impacts of variation orders (cost overrun and time delays). Nine existed highway projects were provided by the MOPWH. The projects have been completed and their accounts were finalized and closed with the same delivery approach: Construction Management (CM) and the same type of contract form: (Unit Price) with drawings and specifications. Because of the missing documents of the completed projects, only the selected projects were found to have full documents concerning the variation orders. For confidentiality purposes, these projects were identified by letters symbols instead of full name, as requested by the owner.

4.2 Impacts of variation orders for the selected projects

The major impacts of variations in the nine selected projects were identified as cost overrun as shown in Table 1. The results on table show that the project D has the highest percentage of variations from the contract award value, where the project F has the lowest percentage.

The delays of the construction works for the nine projects were also identified as time over run as shown in Table 2. The results on table show that the project B has the highest percentage of delays because of variations from the original duration of contract, Where the project I has no delay.

Table 1: Variations Effect on Projects - Cost Overrun

Project	Contract award value (JD)	Variations addition amount (JD)	Final contract value (JD)	variations from contract award value in percentages
A	123310	8104.785	131414.785	6.572
B	132900	31745.73	164645.73	23.886
C	163791.800	28000	191791.800	17.095
D	202400	269888.100	472288.100	133.3
E	80892.500	11741.760	92634.263	10.45
F	2599349.5	139533.17	2738882.67	5.3
G	149500	113689	263189	76.04
H	4,902,600,000	2915539893	7818139983	59.4
I	2581055	331234.864	2912289.864	12.83

Table 2: Variations Effect on Projects – Time overrun

Project	Original Contract duration (days)	Delays (days) as impact of V.O	Revised contract duration (days)	% of delays because of variations from contract original duration
A	60	6	66	10
B	14	26	40	180.5
C	75	88	163	117
D	365	598	963	163.8
E	240	50	290	20.8
F	420	25	435	5.9
G	365	598	963	163.8
H	600	560	1160	90.3
I	30	0	29	-_

4.3 Questionnaire survey

The questionnaire final form is divided into four sections. The first section includes general information about the respondent such as company name, respondent's educational level and experience. This section also includes questions concerning the increasing percentage in projects costs and time due to occurrence of variation orders. The second section addresses and presents the causes of two variation orders by a list of major causes as collected from the related literature. Each respondent is asked to state the degree of this acceptance on these causes. The questions in this section are given in a 5-point rating scale with (1) indicating "strongly agree" with the existence of the condition as a cause and (5) indicating "strongly disagree". An analysis of the causes was further grouped as owner related, consultant related, contractor related and others. Respondents were then given a chance to add other causes and rate them. The third section addresses a list of possible impacts of variation orders, developed from the literature review. Similarity as in the previous section a 5-point rating scale was used starting with "strongly agree" and ending with "strongly disagree".

The last section of the questionnaire addresses issues concerning the adopted systems for controlling the variation orders in the construction industry, and in applying administrative procedures that are set to minimize the occurrence of variation orders. The study population (as a part of questionnaire requirements) includes only thirty of contracting firms Grade (1) and thirty three of consultancy firms Grade (1), as well as a certain numbers of owners who are specialized in highway projects.

The selection of the research sample was based on selecting population size; more than 150 questionnaire forms were distributed. Only 51 responded, representing 34% of the total spread questionnaire forms. The total numbers of the responded includes only eleven contractors and fourteen consultants, as well as a twenty six project owners. Owners were the most cooperative in responding, while the contractors were the least.

4.4 Impacts of Variation Order for questionnaires results

The questionnaires were analyze statically and ranking according to mean and standard deviation. The results indicate that there are thirteen important impacts of variation orders for highway projects in Jordan. Table3 show that the most important impacts was "Completion schedule delay (time overrun)"; its mean was (4.4118) while "Rework and demolition ", was the least important impact addressed; its mean was (2.1569).

4.5 Regression Analysis Model

The weighted arithmetic means were used to identify the most important causes and impacts of variation orders. Also there was a need to prove statistically that there was a relation between the causes and impacts by using multiple linear regressions. Table 4 shows the multiple linear regression analysis of testing the effect of variation order causes on variation orders impacts in highway projects in Jordan from the project participant's responses. The following resulted regression model represents the relation between variation orders causes and impacts:

Table 3: Ranking for the Effect of Variation Orders

Importance of Ranking	Scores	Std. Deviation	Mean	N	Impacts of variation orders
2	Very high	1.1400	4.3137	51	1-Increase in project cost(cost overrun)
1	Very high	0.94181	4.4118	51	2-Completion schedule delay(time overrun)
4	high	1.48667	3.4314	51	3-Hiring new professionals and change project team for complex technology appearance.
3	high	1.31537	3.5686	51	4-Increase in overhead expenses
10	low	1.26243	2.2549	51	5-Delay in payments
8	moderate	1.34631	2.7843	51	6-Quality degradation
12	low	1.28552	2.2157	51	7-Productivity degradation
11	low	1.24239	2.2353	51	8-Procurement delay
13	low	1.04638	2.1569	51	9-Rework and demolition
6	moderate	1.4571	3.2745	51	10-Logistics delays)
9	moderate	1.38082	2.6667	51	11-Tarnish firm's reputation
7	moderate	1.38139	2.8235	51	12-Poor safety conditions.
6	moderate	1.31268	3.3137	51	13-Poor professional relations

Table 4: Multiple Regression Analysis between the Independent and Dependent Variables

Sig.	t	Beta	B	Variables
			Dependent Variable	Causes of variation order
0	4.752	0	0.459	Constant
0	1.003	0.11	0.099	Owner's related Causes
0	4.241	0.904	0.83	Consultant's related Causes
0.002	3.241	0.414	0.395	Contractor's related Causes
0.169	1.399	0.314	0.25	Other related Causes

F-value: 399.155.; R^2= 0.972; Sig. = 0.000

The regression model can be written as bellow:

$Y= 0.459+ 0.099\ X_1 + 0.83X_2 + 0.395\ X_3 + 0.25X_4$

Where: Y: Impacts of variation orders,X_1: Owner's related causes, X_2: Consultant's related causes, X_3: Contractor's related causes, and X_4: Others related causes.

The model shows that the impact of consultant related causes (X_2) is the highest causes of variation orders in highway projects than the other independent variables. The first, third and fourth independents variables causes impact on variation orders in highway projects are the contractor (X_3), other related (X_4), and the owner related (X_1) respectively.

5. Proposition of a Management System for Controlling Variation Orders

The study findings have been employed as foundation for proposing an administration system that could reduce variation orders and, as a result, their impacts when they happen. The application of the system should protect all project stages (conceptual, design and construction). The following is a description of the planned management system through each project phases.

5.1 Conceptual Stage

This phase is the initial phase of construction a project which primarily includes exploring thoughts and deliverables of the project. A set of steps must take place through this stage to prevent any changes in the following stages since this stage is considered as a foundation for the next stages as shown in Figure 1.

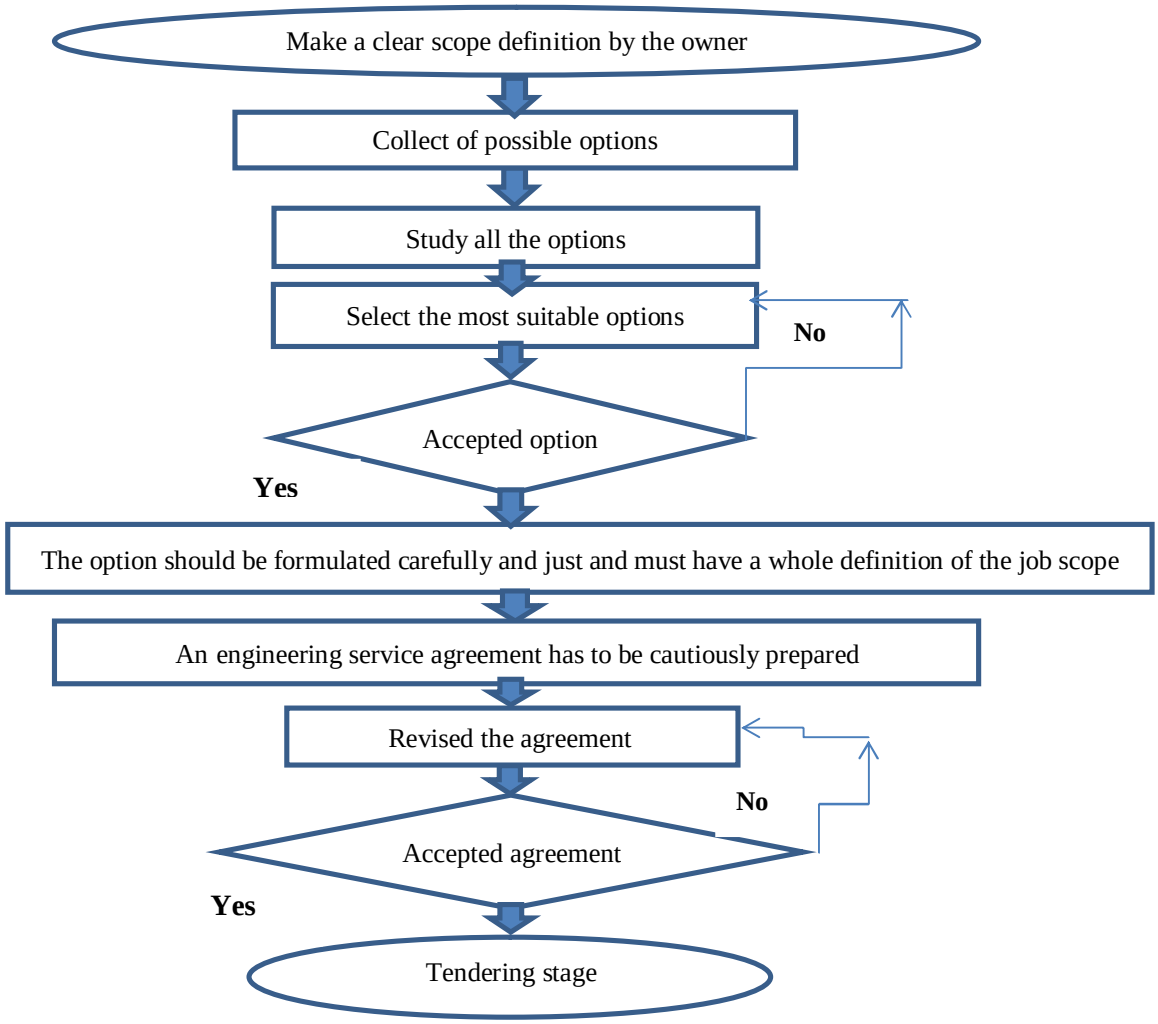

Figure 1: Flow Chart of Proposed Management Control System through Conceptual Phase

5.2 Design Stage

This stage consists primarily of design works and generating of contract files. The design consultant and the owner share the obligation in which the design consultant prepares the design works, while the owner reviews it. The proposed control system is indicating the next action to control variation orders caused by consultant in this phase as shown in Figure 2.

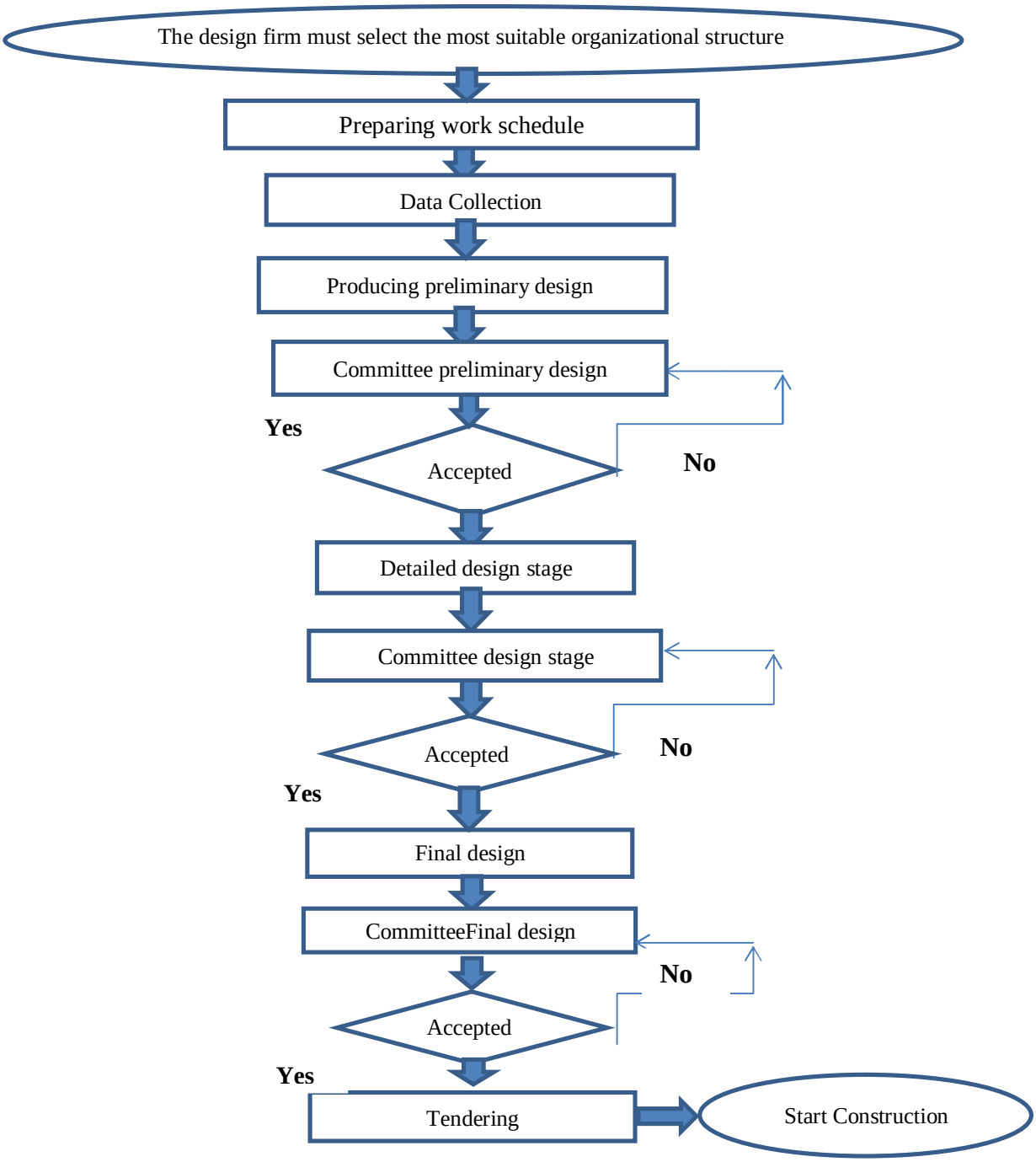

Figure 2: Flow Chart of Proposed Management Control System through Design Phase

5.3 Construction Stage

This third stage of the job lifecycle consists primarily of executing the job drawings. The events involved in this procedure would be the owner; the consultant (Technologist) along with the contractor .The proposed management control system to variation orders is as shown in Figure 3.

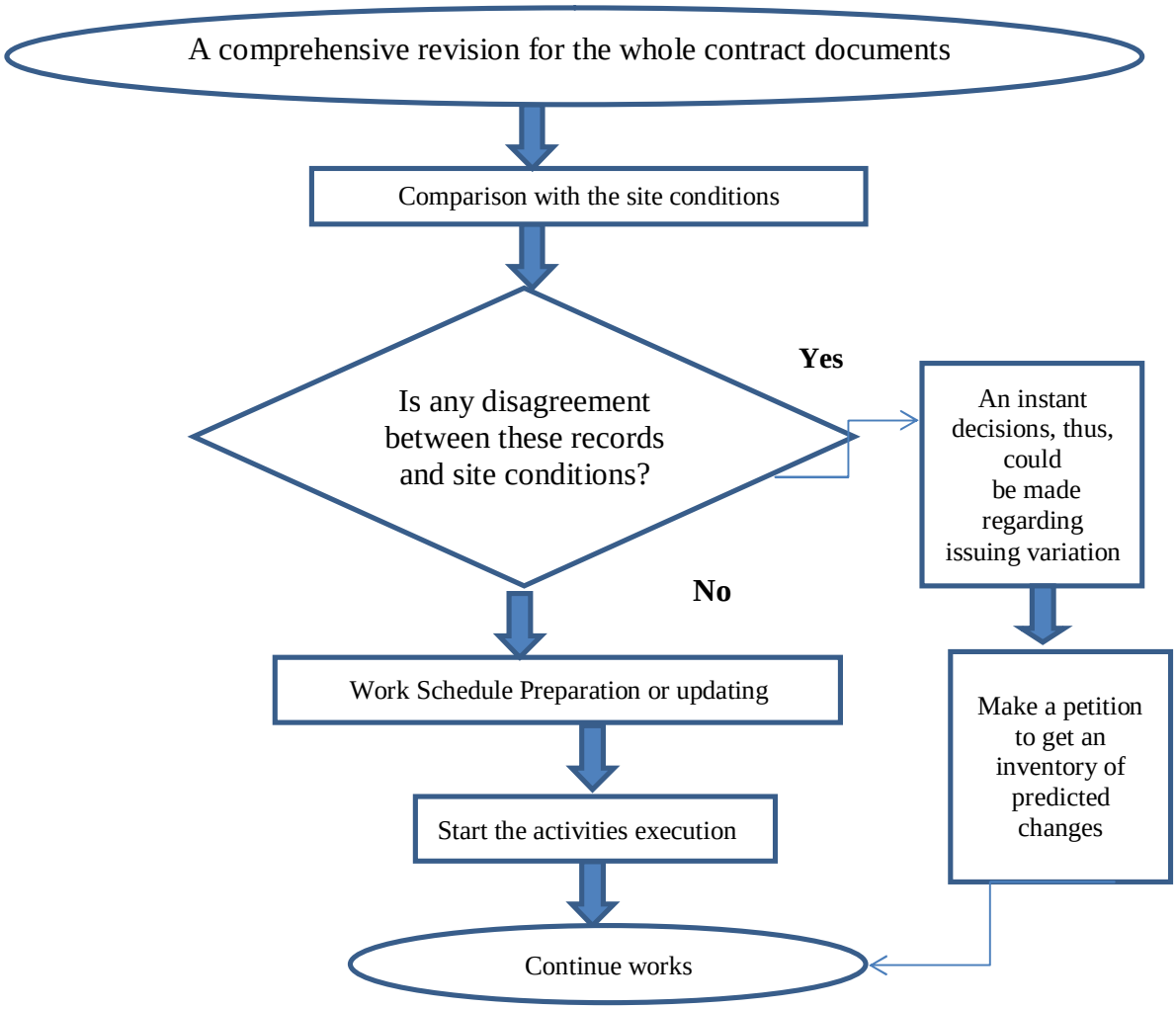

Figure 3: Flow Chart of Proposed Management Control System through Construction Phase

5.4 Evaluation the Applicability of the Proposed Management Control System.

To evaluate the applicability of the proposed management system for controlling the variation orders, an evaluation questionnaire has been used to evaluate the applicability of the proposed system. The evaluation questionnaire consists of a set of questions to be answered by a selected group (twenty respondents) whom were asked before. The responses to the questionnaire is based on a five ordinal measures, Likert scale one being "strongly disagree" and five being "strongly agree" . The results of the evaluation of questionnaire are shown in Table 5. As shown in Table 5, over (50%) of respondents agree on all questions regarding the proposed system, (indicating that respondent's satisfaction with the proposed management control system is very high). The calculated arithmetic mean for all questions shows that all answers on these questions were having score of more than (3), which means that most of participants have a strong positive attitude toward the proposed control system and it will be an efficient technique for controlling the occurrence of variation orders and minimizing their impacts.

Table 5: Answers of the Evaluation Questionnaire

mean	(%) to maximum weight	Repetition weight	No. of repetitions					No. of participants	Statement	NO
			5	4	3	2	1			
4.15	0.83	83	8	7	5	0	0	20	The proposed system could be applied in your projects	1
4	0.80	80	10	4	2	4	0	20	The proposed system is easy, friendly used and comprehensive	2
3.15	0.63	63	5	3	6	2	4	20	The system is comprehensive and covers all the expected causes of variation orders	3
3.7	0.74	74	7	6	3	2	2	20	The system expected to be efficient and will reduce the possible causes of variation orders.	4
4.15	0.83	83	8	8	3	1	0	20	The system is well designed to manage the impacts of the variation orders in term of cost and schedule overruns of the projects	5
4.15	0.83	83	6	11	3	0	0	20	The system is flexible and any modification or improvement could be applied on it during any stage of the project life	6

6. Conclusions and Recommendations

6.1 Conclusions

1. The major owner's related causes are change of plan, change of schedule, and owner's financial problems.
2. The major consultant's related causes are ambiguous design details, inadequate design, conflict between contract documents, and Lack of coordination.
3. The major contractor related causes are unfamiliarity with local conditions, lack of communication, and lack of strategic planning, contractor's desired profitability and contractor's obstinate nature.
4. The major other related to whom causes are safety considerations, socio-cultural factors and unforeseen problems.
5. The major impacts of variation orders are completion schedule delay (time overrun), increase in project cost, and increase in overhead expenses.
6. 6- Of the finished project the maximum percentage of cost overrun have been identified to be more than 130%, also the time overrun have been identified to be more than 180%.
7. A management system has been proposed through the project lifecycle (conceptual, design and construction stages) for controlling the occurrence of variations and then reduces their impacts.
8. The impact of consultant's related causes (X2) is the highest causes of variation orders in highway projects than the other independent variables.
9. The impact of owner's related causes (X1) is the lowest causes of variation orders in highway projects than the other variables.
10. The most popular causes were consultant related causes from the overall results of the causes.
11. The contractor related causes were the least common causes among the overall results of the causes.
12. The causes of variation order according to the position variable, the owner having the highest rank.
13. The causes of variation order according to the position variable, there are no significant differences for any cause.
14. The effect of variation orders according to the position variable, the owner having the highest rank.

15. The effect of variation order differences according to the position variable, there is significant differences between the different participants.
16. The differences were in favor of the owner position as the owner has recorded a higher mean (3.55) compared to the consultant mean (2.50).

6.2 Recommendations

1. The owner should have a clear idea about the project scope to minimize the variation orders.
2. The consultant should be given a reasonable time period for planning a complete, records and design.
3. The owner should perform a comprehensive and integrated study for the projects.
4. Choosing the engineer and contractor should be based on their performance and price qualification not only on lowest price.
5. Designers and owners coordination in the design stage would help to spot the noncompliance of owner's demand and it might help to reduce variation orders in construction stage.
6. Picking of suitable parties to all or any facets of construction process would help owner to cut back variation orders on construction phase.
7. Understanding of achievable project objectives on plan would help all of the undertaking parties (owner, consultant and contractors) to handle the jobs within the acceptable limits of cost and time.
8. Appropriate coordination between all job parties during construction stage would help to accomplish quality, price and time objectives of the task.
9. The planned management control system should be utilized during the project lifecycle to control variations order, and to mitigate the unexpected dangerous impacts of the variations.

References

The Ministry of Public Works and Housing in Jordan (2015).

Arain, F.M. & Pheng, L.S. (2005), 'The Potential Effects of Variation Orders on Institutional Building Projects', Facilities, vol. 23, no. 11/12, pp 496-510

Arain, F.M. & Pheng, L.S. 2006, 'Developers' Views of Potential Causes of Variation Orders for Institutional Buildings in Singapore', Architectural Science Review, vol. 49, no. 1, pp 59-74.

Khalid J. (2012),' Controlling Of Variation Orders in Water and Wastewater Project in Jordan'. MSc.Thesis Isra University.

Koushki, P.A., Al-Rashid K & Kartam, N. (2005), 'Delays and Cost Increases in the Construction of Private Residential Projects in Kuwait', Construction Management and Economics, vol. 23, pp 285-294

Ming Sun, Xianhai Meng, (2009), 'Taxonomy for change causes and effects in construction projects' International Journal of Project Management 27 (2009) 560–572, University of the West of England

Priyantha&Gayani K. (2011), 'Causes, Nature and Effects of Variations in Highways' VAK Rodrigo

Randa S.M., Jawad, M.R & Abang A.A., (2009), Variation Orders in Construction Projects. Journal of Engineering and Applied Sciences, 4: 170-176.

Sambasivan M. & Wen Soon Y. (2006).'Causes and effects of delays in Malaysian construction industry', Ph.D. Dissertation, University of Putra Malaysia.