

Factors Causing Variation Orders and their Effects in Roadway Construction Projects

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Abstract: A major problem in construction projects is variation orders. The goals of this work are to identify the factors responsible for this and to examine its effects on roadway construction projects in south of Iran. Review of previous works on this subject has been limited to developments since the year 2000. In order to obtain the view of many players such as employers, consultants and contractors in the industry on these phenomena, a survey was conducted using a questionnaire. This study was able to isolate 10 critical causes of changes in orders out of as many as 26 causes. It was concluded that change of plans or scope by employer, errors and omissions in design, differing site conditions and contractor's financial difficulties were some of the critical factors causing variation orders in roadway construction projects. Cost and time factors constituted the most visible consequences of variation orders in construction projects. These findings seem to agree with the view of experienced specialists. However, this study is confined to roadway construction projects on south of Iran, nevertheless, the results of construction management problems is common within the developing countries.

Keywords: Causes and effects, change order, construction projects, roadway, variation order

INTRODUCTION

Variation order contains a set of instruction which allows changes or modifications to be made to an earlier agreement in terms of volume or nature of task to be carried out O'Brien (1988). These changes however occur after the award of the initial contract or after work might have commenced at the construction sites. The changes may be due to various reasons such as the modification of scope, schedule, costs and methods.

Change orders are the reasons why most contractors don't meet up with the time specified for completion of most contract works (Pourroostam and Ismail, 2011; Amu *et al.*, 2005). Also, issues relating to funding, design, aesthetic, geological, nature in terms of weather conditions to prospects of construction, statutory changes, product rectification and imbalances between contract documents are some other factors that initiate these variation orders (Hanna *et al.*, 2002). Various previous studies have been dedicated to finding out the genesis of these variation orders in construction projects. It is of great interest that most of the studies have been identified with the building and civil engineering industries as well as general engineering practices. A major factor necessitating variation order is attributable to preference

or taste for enhanced finished product different from the initially agreed quality by the owner in a particular contractual agreement. In addition, there might be modifications to an initial design by consultant weather conditions and differing site conditions (Hsieh *et al.*, 2004).

Many research works have been carried out by experts in the construction industry on the effects of variation orders. According to Hsieh *et al.* (2004), 10-17% ratio of change order cost to total project cost is related to metropolitan public works in Taiwan. It was shown by Ndiokubwayo and Haupt (2011) that 63% of site instructions culminated in additional works and he then suggested that more attention should be devoted to the design stage such that issue of variation order can be minimised. They also showed that 14% of all site instructions are accompanied by wastages most especially those involving modifications to already completed works. In addition, an investigation of the consequences of variation orders on institutional building projects showed they resulted into a substantial increment in amount of funding budgeted for construction works (Arian and Pheng, 2005). It has been proved by several authors that variation orders are responsible most cases of inability to complete and hand over project works as

agreed initially at the commencement of the work (Chan and Yeong, 1995). Also, increment in the project cost and an extended duration of completion are the two main effects observed for change orders (Arian and Pheng, 2005). The focus of the current is to investigate the causes of variation orders on roadway construction projects, as well as to identify the effects of variation orders on roadway construction projects in south of Iran.

METHODOLOGY

In the developing countries, there have been a lot of adverse effects on ongoing projects as a result of constant changes in the course of carrying out such projects. The use of questionnaire survey and a review of previous studies were adopted in the current study and the focus was on the causes and impacts of variation orders in roadway construction projects. A comprehensive list of causes and consequences of variation orders was compiled from a review of previous works which comprised of documented observations, opinion and views of various specialists and experts of more than 20 years' experience in the field. The respondents were quantity surveyors, lecturers, directors, site managers and civil engineers. The experience of respondents in roadway construction ranged from four to 30 years and more than 20 of the respondents were of top managerial cadre. The median length of experience in construction was 10 years. All respondents had been involved in administration of variation orders. The questionnaire was divided into three main parts. The first part requested background information about respondents while the second part focused on causes of variation orders and the third part examined the effects of variation orders in roadway construction projects. The overall ranking of most important factors, causes, effects and procedures of change orders control on construction projects was determined by the evaluation of the mean rank score through the use of Statistical Package for Social Science (SPSS) version 18.

The outcome of the exercise as shown by responses monitored via a 5-point Likert scale viz-a-viz: Strongly disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; and strongly agree = 5 indicated that construction works will always be subjected to the phenomenon of variation orders.

This study was conducted in Khouzestan Estate in south of Iran during the 3rd quarter of year 2011, i.e., between June and September.

Causes of variation orders: From the review of previous works carried out in the current study, 26 factors responsible for variation orders were identified and the data collected from the second part of the questionnaire was also analyzed (Table 1). The 10 most important mean

Table 1: Causes of variation orders in construction projects

S. No.	Causes of variation orders in construction projects
1	Owner's financial problems
2	Change of plans or scope by owner
3	Substitution of material or procedures
4	Design change originated by owner
5	Change in design by engineer or consultant
6	Conflict between contract documents
7	Errors and omissions in design
8	The scope of work for the contractor is not well defined
9	Value engineering
10	Technology change
11	The lack of coordination between consultant and contractor or subcontractors
12	Differing site conditions
13	Contractor's financial difficulties
14	The required labour skill are not available
15	The required equipment and tools are not available
16	Workmanship or material not meeting the specifications
17	Contractor desire to improve his financial conditions
18	Previous construction delay by other contractors working on different contracts
19	Acceleration of work
20	Safety consideration/emergency field condition
21	Weather condition
22	New government regulations
23	Demolition and re-work
24	Strikes
25	Quality improvement
26	Conflict in the project site

rank scores were computed for each cause from the perspective of the employer, consultants and contractors score through the use of SPSS (Table 2).

Based on Table 2, change of plans or scope by the owner was identified as the greatest cause of variation orders from all the viewpoints. Errors and omissions comes second under the ranking while both differing site conditions and contractor's financial difficulties jointly take the third position in the order of the causes of variation orders. Jointly following this on the same ranking scale are weather condition and conflict in the project site, these two occupy the fourth ranked cause of variation order. Following this is the owner's financial problem which occupies the 5th rank. Engineering value and quality improvement jointly occupy the 6th most important factor causing variation order. The least factor responsible for variation order from the perspective of all the groups is acceleration of work.

Spearman rank correlation coefficient was calculated according to the following formula (Assaf and Al-Hejji, 2006):

$$r_s = 1 - \frac{6 \sum d^2}{N^3 - N}$$

r_s = Spearman rank correlation coefficient.

d = Difference in ranking between the contractors and the consultants

N = Number of variables

Table 2: The 10 most important mean rank of causes of variation orders in construction projects

Causes of variation order	Mean employer	Rank employer	Mean consultant	Rank consultant	Mean contractor	Rank contractor	Overall mean	Rank overall
Employer's financial problems	3.63	4	3.43	5	3.71	4	3.59	5
Change of plans or scope by employer	4.13	1	4.14	1	4.29	1	4.18	1
Errors and omissions in design	3.87	2	3.71	3	4	2	3.86	2
Value engineering	3.5	5	3.29	7	3.43	6	3.41	6
Differing site conditions	3.75	3	3.86	2	3.71	4	3.77	3
Contractor's financial difficulties	3.87	2	3.57	4	3.86	3	3.77	3
Acceleration of work	3	7	3.14	8	3	7	3.05	7
Weather condition	3.75	3	3.43	5	3.86	3	3.68	4
Quality improvement	3.38	6	3.29	6	3.57	5	3.41	6
Conflict in the project site	3.63	4	3.71	3	3.71	4	3.68	4

Table 3: The 5 most important effects of variation orders in construction projects

Effects of variation orders	Mean employer	Rank employer	Mean consultant	Rank consultant	Mean contractor	Rank contractor	Overall mean	Rank overall
Delay in completion schedule	4.29	1	4.14	1	4.13	1	4.18	1
Increase in project cost	4	2	3.71	2	3.87	2	3.86	2
Disputes between owner and contractor	3.86	3	3.57	3	3.87	2	3.77	3
Additional revenue for contractor	3	5	3.29	4	3.13	4	3.14	5
Decrease in quality of work	3.57	4	3.29	4	3.38	3	3.45	4

The value of the Spearman rank correlation coefficient ranges from +1 (perfect correlation), to 0 (no correlation), to -1 (perfect negative correlation). The results of the correlation between employer and consultant, employer and contractor as well as between consultant and contractor were 0.87, 0.97 and 0.91, respectively. Generally, these results show a low correlation between the owner and the contractor, while there was a good correlation between the employers and the contractors with 97% agreement.

Effects of variation orders: The third part of the questionnaire examined the effects of variation orders in roadway construction projects from literature review and some of the activities of previous researchers in this area making use of 20 interviews conducted within the top project management level. 17 important factors were identified. The 5 most important mean rank scores were computed for each effect from the perspective of the employer, consultants and contractors score through the use of SPSS (Table 3). Table 3 shows that delay in completion schedule is the most visible effect of variation orders from all the viewpoints. Increase in project cost and disputes between owner and contractor were, respectively the second and third important effects of variation orders from all viewpoints thus ranking second and third, respectively. The spearman rank correlation coefficient was computed as above. The results of the correlation between employer and consultant, employer and contractor as well as between consultant and contractor were 0.66, 0.95 and 0.58, respectively. The Spearman rank correlation coefficient shows that there is a slight agreement between the consultant and the other two parties (0.66 with owner and 0.58 with contractor) while there exist a very close results and high agreement between employer and contractor (0.95).

CONCLUSION AND RECOMMENDATIONS

This study which was conducted in an estate in the southern part of Iran has been able to isolate the causes and effects of variation orders in construction projects. The projects under review in the current study were roadway construction projects in south of Iran from 2001 to 2010. It was observed that change of plans or scope by employer, errors and omissions in design and owners' financial problems were the critical factors that cause the existence variation orders in roadway construction projects. In addition, the results show that time and cost overruns and disputes had great significant effects on project performance. It is to the advantage of this study that its applications are very relevant not only in Iran's roadway construction system but also in other developing countries construction industries. The following recommendations from this study are proposed in order to minimise cases of variation order in construction projects:

- Specialists and experts must be involved in the design planning and process stages of the construction work in order to explain and provide solutions to technical bottlenecks
- A detailed design would be able to exert control to unnecessary interference from consultants or other external influences
- The provision of an elaborately detailed project brief will eliminate frequent variations to the original plan of the project as it would have taken care of all the necessary information and explanations on each step of the project stage

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