Integrated Solutions for Infrastructure Development
Edited by Lau, H. H., Tang, F. E., Ng, C. K., and Singh, A.

ISBN: 978-0-9960437-3-1

CAUSES OF VARIATION ORDERS FOR MEGA CONSTRUCTION PROJECTS

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Variations or change orders are inevitable in any construction project. They are defined as any change that happens in the scope of the project. Change is an additional scope of work, omission, or even alteration. This paper presents the main causes of variation orders in MENA region represented by Egypt. The research investigates the causes, as identified by clients, consultants, and contractors. It classifies them into four main categories: owner related, contractor related, consultant related, and other causes. The top 10 most important causes are ranked among the opinion of each party. The study reveals that the top 3 causes are: 1) The client instruction of additional works; 2) The contractor using ambiguous areas in the contract to request variations, and 3) continuous changes in the project schedule. A comparison about causes of variations was performed between Egypt, Palestine, Malaysia, and the United Kingdom. Furthermore, a model is proposed to provide the user with a scale that predicts the effect of the events triggering variations on both project cost and time.

Keywords: Change, Construction, Civil, Middle East, Variations.

1 INTRODUCTION

A variation order is any modification in the original scope of the contract. Changes may be issued by a contractor's claim, a designer's modification of drawings, or the owner's change in his requirements. A variation order could be as small as changing a window type to as large is omitting the construction of a building in a complex of buildings. The variation order is formally issued to announce the modification of the contract between the contractor and the owner. It recognizes that there is a change in the assigned work without having to resort to a new contract (Hester 1991).

In any construction project, time and money are usually of an extreme essence. Variations are one of the processes that prolong the end time of the project and extrapolate the value of it as well. Many authors such as: Keanne *et al.* (2010), Memon *et al.* (2014) have highlighted the most recurrent problems that are generated due to rise of variations.

Limited studies were carried to understand the causes of variations in the Middle East and more specifically in Egypt. Hence, there is a gap of understanding the events that lead to such variations.

The aim of this study is to identify and rank the most common types of events that lead to variation orders for projects designed and constructed in Egypt. A guidance model, using the collected data, is developed to predict the severity of the combined effect of causes of variations. The model is further verified and validated with a case study.

The followed research methodology in this study starts with a literature review of events that gives rise to variations, their effects, and their rectification methods. A comprehensive survey is conducted among experts to identify the most common types of variations and their ranking in the Egyptian construction industry. Finally, the proposed model is developed, verified, and validated.

In this paper, events that lead to variations are categorized into four categories, namely; client related, contractor related, consultant related, and others.

2 DATA GATHERING AND CALCULATION OF RELATIVE IMPORTANCE FACTOR

The purpose of the gathered data is to identify and rank the top ten most frequent events that give rise to variations. The main components of the survey are:

1 A top ten list for most common events that give rise to variations according to the client, the contractor, and the consultant

2 Probability of the effect of the event that gives rise to variation on project cost

3 Probability of the effect of the event that gives rise to variation on project time

Given the complexity of the survey, and the importance of getting reliable data, only professionals with more than 15 years of experience in the market were included. 25 professionals were selected; all of them with previous experiences in projects with a value exceeding 100 million USD. The participants representing clients were nine and participants representing contractors and consultants were eight each. The reason why there are equal numbers of surveys for each party is to be able to create a reasonable comparison of results between them.

2.1 Calculation of the Average Values Using Relative Importance Factor

In order to obtain the average values for the causes of variation orders, the relative importance factor method (RII) was proposed. The RII was adopted in many previous studies to rank the events that lead to variations: Memon *et al.* (2014), Alnuaimi *et al.* (2010), and Muhwezi *et al.* (2014). The equation of the relative importance factor used was:

$$Score = \frac{\sum W}{H \times N} \times 100 \quad (1)$$

The RII is basically an average of the values obtained ranging from 1 (being lowest) to 5 (being highest), where:

W: summation of all the values given from the experts

H: Highest rating score, which is 5 in this case

N: The total number of respondents

Equation 2 presents the calculation method for confidence intervals to test the upper and lower boundaries of data calculated to rank the causes where:

$$\text{Confidence Interval} = \overline{\text{X}} \pm 1.96 \frac{\sigma}{\sqrt{\text{n}}} \quad (2)$$

$\overline{\text{X}}$ = Average value of the cause; σ = Standard deviation; n = Sample size; 1.96 = constant coefficient (For 95% confidence level)

3 RESEARCH RESULTS

The analyzed results based on the collected data are presented in Table 1.

Table 1. Results of top 10 overall important factors that lead to variations.

Top 10 overall important factors	Score	Confidence Int.
Client instructs additional works	84.44	77.63-91.17
The contractor uses the grey areas in the contract to request variations	78.89	72.36-86.04
Continuous change in project schedule	77.22	68.95-85.45
Conflicts between contract documents	76.94	70.67-82.93
Lack of coordination among project parties	76.94	70.67-82.93
Client's brief before the design stage are unclear or not well defined	75.28	69.68-80.72
Contractor's financial difficulties	75.28	69.23-81.17
Client fails to make decisions at th6e right time	72.50	65.33-80.27
Lack of contractor's involvement in design	72.22	64.01-80.79
Modification of scope	71.67	64.49-79.51

Table 1 presents the overall assessment of events. The overall assessment is the average of the contractor, client, and consultant's data. Topping the list is *client's instruction of additional works* which has always monopolized the top two spots among the results. It can be confidently drawn that this is the main and the most frequent cause of variations. Its average value among all the parties scored a value of 84.44. *The contractor using the grey areas in the contract to request variations* took number two in the list because it was given a high score value of 78.89 from the client and from the consultant. *Continuous changes in project schedule* scored 77.22 while *conflicts between contract documents and lack of coordination* came in fourth and scored 76.94.

3.1 Comparison between the Top Ten Important Factors for Each Party

The analyzed results based on the collected data for each party are presented in Table 2.

Table 2. Results of top 10 overall important factors for every party.

#	Top 10 important factors for client	Top 10 important factors for contractor	Top 10 important factors for consultant
1	The contractor uses the grey areas in the contract to request variations	Client instructs additional works	Client instructs additional works
2	Client instructs additional works	Client's brief before the design stage are unclear or not well defined	Continuous change in project schedule
3	Client fails to make decisions at the right time	Conflicts between contract documents	The contractor uses the grey areas in the contract to request variations
4	Modification of scope	Lack of coordination among project parties	Contractor's financial difficulties

#	Top 10 important factors for client	Top 10 important factors for contractor	Top 10 important factors for consultant
5	Short period for design stage	Poor construction management by contractor	Change in specification by owner/client
6	Lack of contractor's involvement in design	Non availability of professional engineers to maintain the quality of consultancy services	Lack of contractor's involvement in design
7	Continuous change in project schedule	Poor workmanship	Conflicts between contract documents
8	Client's brief before the design stage are unclear or not well defined	Contractor's financial difficulties	Lack of coordination among project parties
9	Contractor's financial difficulties	Continuous change in project schedule	Low consultancy fees leading to hiring less experienced designers
10	Conflicts between contract documents	Change in specification by owner/client	Client fails to make decisions at the right time

If a conclusion can be drawn here, it would be that each party is biased towards its own benefit. An example can be stated by observing that both the client and the consultant think that "*the contractor uses the grey areas to request variations*" is one of the top reasons why variations are generated. Another example can be noticed is that both the contractor and the consultant think that one of the main reasons variations occur is because the tendency of the client to "*change project specifications".*

3.2 Comparison of the Overall Results with Other Studies

The results in table 3 are showing a comparison of the top five causes of variations in four countries.

Table 3. Comparison between the results in four different countries.

Rank	Gaza	Egypt (current study)	Malaysia (Memon, Abdul Rahman, & Abul Hasan, 2014)	UK (Keanne, Sertyesilisik, & Ross, 2010)
1	Lack of construction materials & equipment	Client instructs additional works	Unavailability of equipment	Errors and omissions in design
2	spare parts due to closure and siege	The contractor uses the grey areas in the contract to request variations	Poor workmanship	Little involvement in design from contractor
3	Change in design by consultant	Continuous change in project schedule	Design complexity	Inadequate project objectives
4	Lack of consultant's knowledge of available materials and equipment	Conflicts between contract documents	Change in schedule	Poor design
5	Errors and omission in design	Lack of coordination among project parties	Impediment to prompt decision making process	Conflicts between contract documents

It can be observed that there is no solid overall similarity between these top five causes for the different countries. This would support a conclusion that events giving rise to variations are very sensitive to regional conditions and would differ from country to another.

4 MODEL DEVELOPMENT AND VALIDATION

A model was developed using the data collected through the research to allow the user to select a number of events which he/she thinks might happen to the project. The selected events are compared against the database collected and the user gets two results, one for the cost and the other for the time. The results displayed estimate the effect of the events that give rise to variations on project cost and project time. The results depend on the severity of the events on cost and time and ranges from low effect to moderate, up to important and critical. The user gets the display shown in table 4.

The scale calculates the severity of events on project cost and time, if the effect is less than 10% from the maximum calculated score; the result is "low". If the effect is less than 30%, the result is displayed is "moderate", if it is less than 50%, the result is "important". Finally, if the effect is more than 50% of the calculated severity score, then the result displayed is "critical".

Table 4. User display.

Effect on Project Cost	MODERATE
Effect on Project Time	IMPORTANT

4.1 Validation Using Case Study

The model was used against an existing retail shopping center that was finished in Cairo in 2013. The effect of events on cost and time were previously known since it was an already finished project. When the data was entered by an independent user, the model showed comparable results.

5 CONCLUSION

Variation orders are a very important factor in construction projects. They affect the project cost, time, quality, productivity and can have other adverse effects on organizations. Through the course of this study, it was found that the top event that leads to variation orders in Egypt is: client's instruction of additional works. It was also found that the top ranked events leading to variation can vary from one country to another. Finally, a simple easy-to-use model is proposed to evaluate the impact of the variation events on the time and cost of projects.

References

Alnuaimi, A. S., Taha, R. A., Al Mohsin, M., & Al Harthi, A. S., (May 2010), Causes, Effects, Benefits, and Remedies of Change Orders on Public Construction Projects in Oman, *Journal of Construction Engineering and Management* , 615-622.

Hester, T., Kuprenas, A., & Chang., (1991), *Construction Changes and Change Orders: Their Magnitude & Impact*, Construction Industry Institute.

Keanne, p., Sertyesilisik, B., & Ross, A. D., (2010), Variations and Change Orders on Construction Projects, *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 89-96.

Memon, A. H., Abdul Rahman, I., & Abul Hasan, M. F., (2014), Significant Causes and Effects of Variation Orders in Construction Projects, *Research Journal of Applied Sciences, Engineering and Technology*, 4494-4502.

Muhwezi, L., Acai, J., & Otim, G., (2014), An Assessment of the Factors Causing Delays on Building Construction Projects in Uganda, *International Journal of Construction Engineering and Management*, 13-23.