



## Variation Orders in Building Projects in Khartoum State-Sudan: The Causes and the Impact on Projects Performance

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### ABSTRACT

Occurrence of variation orders (VOs) is a common phenomenon in building projects and a challenging feature. Opinions and feedback of the stakeholders of building projects at Khartoum State – Sudan were investigated to identify and rank the key factors that cause VOs and evaluate their consequent impact on projects' performance. 10 projects were thoroughly analyzed to determine how their performance was affected by the occurrence of VOs and in conjunction with this an industry wide survey that was conducted to determine the frequency of occurrence of a previously compiled list of factors. 130 respondents -contractors, consultants, projects' owners and project managers-took part in the survey. Considering the frequency of occurrence and the strength of their impact, the relative importance index from the participants' feedback was calculated allowing the ranking of the factors causing VOs. It was found that the main causes for VOs emerged from the owners' side and are mainly attributed to changing his needs or scope of work. It was also confirmed that there is a significant relationship between the occurrence of VOs and projects' time extension (by 22-200%) and cost overrun (by 2.67-42.86).

**Keywords:** Variation orders; Khartoum; Sudan; Building projects

### 1 INTRODUCTION

The building industry is one of the largest industries in the world. Sudan, as one of the developing countries, put some efforts to commit a reasonable share of their annual budgets for the building sector. With best efforts to execute the projects as planned for, the occurrence of VOs is still a common feature and a recurring phenomenon in most if not all building projects stakeholders in Khartoum State Sudan. VOs depict any deviation from the agreed upon (scope, time, cost or quality) among the project's stakeholders (Osman et al, 2010). Concerns and some preliminary, informal investigations with some construction managers in Sudan, revealed that VOs are viewed as a major source of nuisance leading to contract over budget and time extension problems. Consequently, this study was launched to investigate the root causes of VOs in building projects in Khartoum State- Sudan as viewed from the perspective of all the stakeholders and to evaluate their impact on some selected project performance dimensions.

### 2 PREVIOUS STUDIES

Previous studies that considered the same phenomenon but in their own settings were

consulted. That made it possible to compile a list of factors, which are highlighted as causes of VOs in construction projects. A study in Gaza Strip described 64 factors among which “lack of materials and equipment spare parts, design change by consultant, lack of consultant’s experience, design errors and omission, conflicts between contract documents, owner’s financial problems, lack of coordination among project parties, and change is specification by owners” were the most significant (Enshassi et al., 2010). With a similar study geared towards the investigation of VOs in highway projects, (Wu et al., 2005) differentiated between external and internal causes where he considered the external causes to include factors such as political, economic, natural environmental aspects and third party. On the other hand, he classified the internal causes as those initiated by the owner, construction design consultant, contractor or other parties.

Studies on VOs in Oman, as described by (Alnuaimi et al., 2010) confirmed that clients’ additional works or design modifications come at the top of the list of frequently occurring and most influential factors while adding the unavailability of formal construction manuals and procedures besides some quality related issues as other causes. With a proven adverse impact on project s’ performance, VOs effect on productivity and project costs was reported by (Cox, 1997) who viewed then as unwanted but inevitable source for cost escalation, time overrun and declining quality.

### **3 MATERIALS AND METHODS**

To tackle the stated problem and allow measuring the stakeholders’ opinions regarding the raised concerns, both qualitative and quantitative approaches were adopted.

#### **3.1 Preliminary Investigation**

In the preliminary stage, an in-depth investigation was conducted through the study of 10 building projects developed and executed at the State of Khartoum, Sudan during a range of 8 years covering the period (2007-2015). For each project the contract documents and progress reports were reviewed to provide a clear explanation of the actual deviations that took place and allow spotting the causes and the probable impact on the overall project performance. After defining and meticulously tracking the VOs occurred, the projects’ participants were interviewed to give an account on what they think the actual causes and hence the possible consequences as happening within their context.

#### **3.2 Industry Survey**

The preliminary investigation was followed by an industry-wide survey to validate the preliminary outcomes from the studied cases and to allow generalizing the results. A questionnaire form was designed, tested and translated then devised as a tool to collect the required data. Part of the questionnaire included a close-ended question comprising 28 factors, previously highlighted in the literature and the studied cases, as the main causes of VOs. Depending on their experience, respondents were asked to state the frequency of occurrence of each of the listed factors against a 5-points Likert scale. Another question was devised to measure the possible impact of VOs on the project performance as viewed by the project participants. The participants responded by weighting the impact on cost and time and the weighted average for their feedback was determined.

### 3.2.1 Sample Size and Configuration

The survey participants were client, civil engineering contractors, consultants and project managers and were randomly selected from the official reference lists of the Sudanese Contractors Union and the Council of Organizations of Consultants in Sudan. The sample size was determined on the basis of statistical principles for this type of exploratory research following equations (1) and (2) as described in the literature for this type of research (Yin, 2009; Palinkas et al., 2015):

$$n_0 = (P * q) / V^2 \quad (1)$$

$$n = n_0 / [1 + (n_0 / N)] \quad (2)$$

Where:

$n_0$ : first estimate of sample size,

$P$ : the proportion of the characteristic being measured in the target population,

$q$ : complement of ' $p$ ' or  $1-p$ ,

$V$ : maximum standard error allowed,

$N$ : population size,

$n$ : sample size.

180 responses were targeted from the four major groups who represent the projects' stakeholders. 130 respondents successfully participated in the survey. Table 1 portrays the sample configuration and the response rate.

Table 1: Survey Sample Configuration

Respondents category	Questionnaire		
	Copies distributed	Copies returned	Response rate (%)
Clients	35	23	65.71
Contractors	70	53	75.71
Consultants	60	47	78.33
Project managers	15	7	46.67
Total	180	130	72.2

### 3.2.2 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 21.0. was used for the analysis of the obtained data where the reliability test was performed to measure the degree to which a research instrument (questionnaire) yields consistent results or data after repeated trials. A commonly accepted rule of thumb for describing internal consistency using Cronbach's alpha as described in the literature by (Kombo & Tromp, 2006) is as stated in Table 2.

Table 2: Cronbach's alpha consistency rule

Cronbach's Coefficient Alpha	Internal Consistency Remarks
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	Good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

The Cronbach's alpha coefficient value for the questionnaire was 0.857. This value according to table 2, indicates that the questionnaire items form a scale that has good internal consistency that could be used as a reliable data collection tool.

(RII) was calculated according to equation (3) as described in (Mohammed et al, 2017)

$$RII = (5x_5 + 4x_4 + 3x_3 + 2x_2 + x_1) / (5 * N) \quad (3)$$

Where:

$X_i$ : the number of respondents who selected the option of impact;

N: the total number of respondents.

## 4 RESULTS ANALYSIS AND DISCUSSION

### 4.1 Preliminary results

Table 3 shows the results that emerged from the studied cases. The calculations of the percentage increase in cost and time due to VOs were presented. It is evident for the investigated projects that a substantial majority (75%) of the recorded causes for VOs were related to the owner's changing needs, scope of work, change of materials prices of in local market, changing government regulations and legislation and change in the project use. I was also found that a direct relationship exists between the presence of VOs and the project's time increase. It was noticed that the projects' durations were extended by (22-200) % due to VOs while the cost analysis exercise showed over budget expenses to increase by (2.67-42.86) % due to VOs.

Table 3: Variation orders and their impact on projects' cost and time

Studies Projects	Causes of Occurrence of Variation Orders	Impact of VOs on the Project Dimensions					
		Cost			Time		
		Initial Contract Cost (Million SDG)	Final Contract Cost (Million SDG)	% of Increase in the contract cost	Initial Project Duration (Month)	Final Project Duration (Month)	% of Increase in the project duration
Project (1)	<ul style="list-style-type: none"> <li>Change use of building</li> <li>Design Changes,</li> <li>Instability of prices</li> </ul>	140	200	42.86	24	42	75
Project (2)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Design Changes</li> <li>Instability of prices</li> </ul>	6,	7.5	25	12	16	33
Project (3)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Design Changes</li> </ul>	8	8.42	5.25	18	22	22
Project (4)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Design Changes</li> </ul>	2.5	2.85	14	12	21	75
Project (5)	<ul style="list-style-type: none"> <li>Changing government regulations and legislation</li> </ul>	4	5	25	9	27	200
Project (6)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Change use of building</li> <li>Design Changes</li> </ul>	22	22.91	4.14	20	35	75
Project (7)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Change use of building</li> <li>Design Changes</li> </ul>	17.5	19.9	13.71	12	18	50
Project (8)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Design Changes</li> </ul>	140	161	15	18	54	200
Project (9)	<ul style="list-style-type: none"> <li>Client's changing needs</li> <li>Design Changes</li> </ul>	6	6.16	2.67	18	30	66.67
Project (10)	<ul style="list-style-type: none"> <li>Change the Scope of Work</li> <li>Design Changes</li> </ul>	30	32	6.67	12	22	83

## 4.2 Industry Survey Results

### 4.2.1 Frequency of occurrence of the factors causing VOs

Based on the assertion that VOs could be caused by several factors with a variable impact levels, the weighted averages for respondents' opinions made it possible to rank the factors depending on the frequency of their occurrence as depicted in table 4.

The results showed that the most frequently occurring factors causing VOs are:(1) Lack of stability of prices and the exchange rate change, (2) New government regulations, (3) Non availability of construction manual and procedure for construction project in Sudan, (4) Errors and omissions in design ,two factors in the same ranking (5) Owner fails to make decisions or review document at the right time and Owner's needs during the design stage are not well-defined or variably , (7) Owner's financial problems ,two factors in the same ranking (8) Contractors financial difficulties and The lack of coordination between consultant and contractors and subcontractors and (10) Non-use value engineering in design stage to find the best alternatives and providing cost.

Table 4: Factors causing VOs and their impact on cost and time

Factor	Factor Description	Very Often	Often	Sometimes	Seldom	Never	Relative Importance Index
F 1	Owner's financial problems	74	33	15	3	5	0.86
		56.92%	25.38%	11.54%	2.31%	3.85%	
F 2	Change of plan by Owner	75	20	25	9	1	0.84
		57.69%	15.38%	19.23%	6.92%	0.77%	
F 3	Change of Scope by Owner	72	28	21	6	3	0.85
		55.38%	21.54%	16.15%	4.62%	2.31%	
F 4	Owner fails to maintain hold on the project schedule.	69	21	24	12	4	0.81
		53.08%	16.15%	18.46%	9.23%	3.08%	
F 5	Owner fails to make decisions or review document at the right time.	85	24	15	4	2	0.89
		65.38%	18.46%	11.54%	3.08%	1.54%	
F 6	Owner's needs during the design stage are not well-defined or variably.	87	21	15	5	2	0.89
		66.92%	16.15%	11.54%	3.85%	1.54%	
F 7	Change in design by engineer or consultant	64	27	25	8	6	0.81
		49.23%	20.77%	19.23%	6.15%	4.62%	
F 8	Conflict between contract documents	81	19	14	8	8	0.84
		62.31%	14.62%	10.77%	6.15%	6.15%	
F 9	Errors and omissions in design	90	22	9	4	5	0.89
		69.23%	16.92%	6.92%	3.08%	3.85%	
F 10	The scope of work for the contractor is not well defined	80	16	20	7	7	0.84
		61.54%	12.31%	15.38%	5.38%	5.38%	
F 11	Technology changes	72	26	16	7	9	0.82
		55.38%	20.00%	12.31%	5.38%	6.92%	
F 12	The lack of coordination between consultant and contractors and subcontractors	84	17	18	3	8	0.86
		64.62%	13.08%	13.85%	2.31%	6.15%	
F 13	Differing site conditions	76	17	19	5	13	0.81
		58.46%	13.08%	14.62%	3.85%	10.00%	
F 14	Contractors financial difficulties	82	21	15	6	6	0.86
		63.08%	16.15%	11.54%	4.62%	4.62%	
F 15	The required labor skill are not available	76	23	17	12	2	0.84
		58.46%	17.69%	13.08%	9.23%	1.54%	
F 16	The required equipment and tools are not available	72	23	17	11	7	0.82
		55.38%	17.69%	13.08%	8.46%	5.38%	
F 17	Material not meeting the specifications	72	17	14	9	18	0.78
		55.38%	13.08%	10.77%	6.92%	13.85%	
F 18	Contractor desire to improve his financial conditions	72	19	13	8	18	0.78
		55.38%	14.62%	10.00%	6.15%	13.85%	

F 19	construction delay by other contractors working on different contracts	80	21	11	15	3	0.85
		61.54%	16.15%	8.46%	11.54%	2.31%	
F 20	Acceleration of work Safety consideration / emergency field conditions	67	26	14	15	8	0.80
		51.54%	20.00%	10.77%	11.54%	6.15%	
F 21	Weather conditions	70	16	18	17	9	0.79
		53.85%	12.31%	13.85%	13.08%	6.92%	
F 22	Demolition and re-work	60	22	14	13	21	0.73
		46.15%	16.92%	10.77%	10.00%	16.15%	
F 23	Difference between the design and the actual construction on site	76	13	16	9	16	0.79
		58.46%	10.00%	12.31%	6.92%	12.31%	
F 24	New government regulations	99	19	8	4	0	0.93
		76.15%	14.62%	6.15%	3.08%	0.00%	
F 25	Lack of stability of prices and the exchange rate change	107	17	3	3	0	0.95
		82.31%	13.08%	2.31%	2.31%	0.00%	
F 26	Non-use value engineering in design stage to find the best alternatives and providing cost	86	14	14	11	5	0.85
		66.15%	10.77%	10.77%	8.46%	3.85%	
F 27	Non availability of construction manual and procedure for construction project in Sudan	97	16	10	3	4	0.91
		74.62%	12.31%	7.69%	2.31%	3.08%	
F 28	Obstinate nature of owner and consultant	60	17	10	19	24	0.71
		46.15%	13.08%	7.69%	14.62%	18.46%	

#### 4.2.2 Impact of VOs on projects' time and cost performance

With a variable impact level, respondents were asked to give their opinion to help gauging the impact of VOs on projects' performance. The results obtained are as presented in Table 5.

Table 5 shows the respondents' feedback summary on weighting the impact of VOs on projects' performance. That included workers decreased productivity, (2) Increase the cost of the projects, (3) Delay in completion schedule, (4) Disputes between owners and contractor, (5) Decrease in quality of work, (6) Increase in overhead expenses, (7) Increase in duration of individual activities, (8) Demolition and re – work, (9) Delay in payments (10) Hold on work in other areas, (11) Additional money for contractor.

Table 5: Impact of VOs on projects cost and time performance

Impact	very Often	Often	Sometimes	Seldom	Never	Relative Importance Index
Increase the cost of the projects	89	30	11	0	0	0.92
	68.46%	23.08%	8.46%	0.00%	0.00%	
Increase in duration of individual activities	68	33	13	13	3	0.83
	52.31%	25.38%	10.00%	10.00%	2.31%	
Delay in completion schedule	94	17	9	7	3	0.90
	72.31%	13.08%	6.92%	5.38%	2.31%	
Delay in payments	75	18	14	13	10	0.81
	57.69%	13.85%	10.77%	10.00%	7.69%	
Demolition and re – work	78	15	16	15	6	0.82
	60.00%	11.54%	12.31%	11.54%	4.62%	

Decrease in productivity of workers	97	19	11	3	0	0.92
	74.62%	14.62%	8.46%	2.31%	0.00%	
Increase in overhead expenses	82	21	7	15	5	0.85
	63.08%	16.15%	5.38%	11.54%	3.85%	
Decrease in quality of work	91	18	7	6	8	0.87
	70.00%	13.85%	5.38%	4.62%	6.15%	
Disputes between owners and contractor	91	15	12	12	0	0.88
	70.00%	11.54%	9.23%	9.23%	0.00%	
Hold on work in other areas	68	15	19	12	16	0.76
	52.31%	11.54%	14.62%	9.23%	12.31%	
Additional money for contractor	66	13	13	17	21	0.73
	50.77%	10.00%	10.00%	13.08%	16.15%	

## 5 CONCLUSION

The results obtained from this study displayed the major factors causing VOs, confirmed that they emerged from the owners' side, and are mainly attributed to changing his needs or scope of work. It was also confirmed that there is a significant relationship between the occurrence of VOs and projects' time extension (by 22-200%) and cost overrun (by 2.67-42.86).

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