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Variation Orders Add or Non Value Add- A Case of South Africa

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Abstract

Construction project rarely reach completion stage without variation orders being issued by the client's representative, and variation orders can be good and bad for the project. Moreover, variation orders cannot be avoided completely, they can be minimised or prevented if their origin and causes are clearly known. The greater the knowledge and awareness of non-value adding activities associated with variation orders, the greater the prospect of their avoidance and consequent reduction of overall construction delivery costs. This paper focuses on variation as a value add or wastage. Quantitative approach was adopted for this study, structured questionnaires were distributed online and 159 were received and analysed. The questionnaire was distributed to various construction professionals and contractors. Factor analyses was conducted, correlation matrix, coefficients has also been conducted to ensure visibility of co-effincients greater than 0.3 and Kaiser- Meyer- Oklim (KMO) and Bartletts were conducted. From the study it transpired that waste of time, which resultant more labour charges, waste due to wrong use of material or wrongly specified, time and cost reduction, waste of material after demolition of a portion of work, compensation waste of resources such as unnecessary increased project budget, waste due to uneconomic use of machinery or lying idle on site due to change orders were the non value add of the variation orders. This non value add variation orders affect the productivity of construction projects. Therefore, proper channels of communication and planning should be in place, to reduce the occurrence of variation orders in construction projects.

Keywords

Demolition, Idle, labour, Materials.

2. 1. Introduction

Variation orders are any modification to the contractual guidance that are issued to the contractor by the client or clients representative (Arai & Pheng, 2005, Alhilli & Rezoqi, 2021). Variation orders often involve additional cost and disruption to work under way, leading to cost and time overruns (Bower, 2000). According to a study conducted in Kuwait by Koushki, Al-Rashi & Kartam, (2005), revealed that a number of variation orders issued during the construction phase has led to both delays and cost increases. In their study they further confirmed that, the project under investigation incurred more than 58% time delay and cost increases due to variation orders (Koushki et al. 2005). There are some unusual circumstances where variations costs accounted for as much as 100 percent more thanthe budgeted funds, the industry norm has been determined to be 10 percent (Arain & Pheng , 2005). According to a study done by Oladapo, (2007) regarding variation orders in construction projects, they found that variation orders contributed to the average cost escalation of 7% and 30% time extension more than the original project duration. Moreover, the ocurrence of variation orders seems inevitable in developing countries, where infrastructure and buildings are being upgraded with newly built ones including the constant change in the market. In-addition, Love , et al, (2019), noted that a degree of change should always be expected as it is difficult for clients to visualise the end product they procure. Although, it is likely that variations orders cannot be avoided completely, they can be minimised or prevented if their origin and causes are clearly known (Mohamed, 2001, Khalifa & Mahamid, 2019). The greater the knowledge and awareness of non-value adding activities associated with variation orders, the greater the prospect of their avoidance and consequent reduction of overall construction delivery costs. There are variation orders which may be seen as counter to the likelihood that they become time consuming and costly elements on construction projects (Mohamed, 2001 and Khalifa & Mahamid, 2019). Therefore, success in managing variation orders results in uninterrupted construction operations and agreed project costs as well as durations (Khalifa & Mahamid, 2019).

2. Variation contributing to wastage

Wastage has various meaning in the construction space, very often wastage has been referred to as a physical loss of material occurring during the construction process (Osman, Omran & Foo, 2009). Some authors defined waste beyond physical losses of materials. Memon, Rahman & Hasan, (2014), defined waste as anything that adds no value to producing the required services.

2.1 Waste associated with variation orders

The paradigm of waste in construction has various meanings depending on one's point of view. Very often, waste has been referred to as physical losses of material occurring during the construction process.Osman, Omran & Foo, (2009), argued that most studies on waste are based on the conversion model in which material losses are considered to be synonymous to waste. According to Osman, Omran & Foo, (2009), waste is defined as any inefficiency that results in the use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of the building. However, it should be understood that the contractor recognises allowable waste as the percentage for losses of material allocated to bill rate components by the estimator at tender stage and it varies from one material to another. For example, stockpile material such as sand and gravel may be allocated a higher percentage while countable material such doorframe, may be allocated null waste Memon, Rahman & Hasan, (2014). Unfortunately variation orders contribute to the occurrence of wastage of material such as cement that hardens in the stores following an instruction to suspend work. This item is mostly overlooked and not allocated to the variation order account and the contractor suffer the loss. Waste of materials resulting from variation orders may occur in the following circumstances:

1. Compensating waste arising when material ordered for one specific purpose is used for another. For example, face bricks ordered for external wall erection may be used for internal plastered walls when there is a shortage of common bricks, or change of specification like installing shopfront instead of bricks.
2. Waste due to the uneconomic use of plant arising when the plant lies idle on site as a result of a variation order. Memon, Rahman & Hasan, (2014), estimated the waste for non-productive use of resources at more than 10% of a project's production cost.
3. Waste of materials due to incorrect decision, inconsistence inspection of works by the project consultant.
4. Waste of materials after demolition of a portion of work caused by the variation order to change a trade. For example, waste for breaking a wall to accommodate a window.
5. Waste due to wrong use of material or waste stemming from materials wrongly specified.

2.2 Non value add variation orders

According to Koushki et al. (2005) a significant cost and time reduction can result if a complete design is presented to the client before commencement of construction work. Whenever a variation order is issued, whether leading to additions, alterations, omissions or substitution, unnecessary costs are likely to be incurred. Construction professionals should be able to determine and quantify non value adding cost associated with variation orders. The realistic quantification of such costs is problematic due to lack of appropriate techniques for their measurement. In practice, non value adding cost which arises from variation orders are then transferred to the client and most of the time are underestimated. For example, one may be able to calculate the costs of aborted works, but non value adding cost arising from non-productive time, redesign and overheads are not attributed to such an activity (Koushki et al. 2005).

Furthermore, Alhilli & Rezoqi, (2021), indicated that every time a task is divided into two subtasks executed by different specialist, non value-adding activities increase. By uncovering non value adding activities arising from variation orders it is possible to take proactive measures to reduce them. A clear understanding of variation orders and subsequent waste is possible if they are categorised by their origin and identification of possible waste zones. Alhilli & Rezoqi, 2021suggested a framework formation of waste and value loss that takes into account the following:

- Waste and value loss
- Factors causing loss and
- Root causes

Similarly, when a variation order is issued, numerous non value adding activities/ costs are likely to arise. These include unplanned site meetings, travelling and communication expenses, idle plant and labour during the waiting time, demolitions, time taken by the designer to understand the required change and redesign, cost and time for litigation in case misunderstanding arises between the contractor and the client or his/her consultant. These represent a waste of resources and are typical paid for by the client. Variations orders do not only affect project performance in terms of time and cost, they also adversely affect the quality, health and safety and professional relations (Arain & Pheng, 2005). Factors influencing the occurrence of variation orders and their adverse impact on project performance vary from one project to another. Factors include the nature of works, the complexity of the project and the procurement method. The integration and implementation of the new trend technology may reduce the occurrence of variation orders on construction project. Digital technology will reduce the occurrence of variation orders, improve productivity, improve safety, improve professional relations among stakeholders and will encourage the usage of limited resources wisely.

3. Methodology

Quantitative approach was adopted for this study. The data was collected through primary and secondary sources, 159 structured questionnaire were received from the construction stakeholders which were then analysed. A five point Likert scale was used to determine the impacts of variation orders on construction projects. The adopted scale was as follows: 1= To no extent, 2= Small extent, 3= Moderate extent, 4=Large extent, 5= Very large extent. The computation of the mean item score (MIS) was calculated from the total of all weighted responses and then relating it to the total responses on an aspect. After mathematical computations, the criteria were then ranked in descending order of their mean item score (from the highest to the lowest). The test of hypothesis was conducted through the factor analysis. These include the assessment of the suitability of data for analysis; Correlation matrix coefficients to ensure visibility of coefficients greater than 0.3, Kaiser-Meyer- Olkim (KMO) and Bartlett ‘s test was conducted. Kaiser’s criterion used as it applies the eigenvalue rule to eliminate and extract factors. Any factor with eigenvalue which was less than one (1) was eliminated and greater than one (1) was retained.

4. Results

4. 1 Descriptive analyses

Table 1 present the variation order factors that contribute to wastage on construction performance in South Africa. The factors were tested for validity and internal reliability. A five point Likert scale was used where: 1= To no extent, 2= Small extent, 3= Moderate extent, 4=Large extent, 5= Very large extent. Certain abbreviations and number of range were established to present results outcomes accordingly. Table 1 below indicate the variation orders that contribute to wastage on construction performance: Waste of time, which results in more labour charges was ranked first with (mean (M)=4.81; Standard deviation (SD)= 0.493; Cronbach alpha (α)= 0.945; Rank (R)=1); Waste due to wrong use of material or wrongly specified with (M=4.74; SD=0.705; α=0.939; R=2); Time reduction with (M=4.73 ; SD=0.752; α=0.940; R=3); Reduction in cost with (M=4.72; SD=0.737; α=0.939; R=4); Waste of material after demolition of a portion of work with (M=4.72; SD= 0.684; α=0.942; R=4). Compensating waste of resources such as unnecessary increased project budget with (M=4.72; SD= 0.657; α=0.949; R=4); Waste due to uneconomic use of machines (machines lying idle on site) with M=4.70; SD=0.612; α=0.942; R=5); Material wastage due to incorrect decisions with (M=4.67; SD=0.689; α=0.937; R=6); Waste reduction with (M=4.67 SD= 0.743; α=0.944; R= 6).

Table 1. Variation order contributing to wastage

Item	Description	N	Mean	Std. Deviation	crobach's alpha	Rank
E18.6	Waste of time, which results in more labour charges	159	4.81	0.493	0.945	1
E18.5	Waste due to wrong use of material or wrongly specified	159	4.74	0.705	0.939	2
E19.3	Time reduction	159	4.73	0.752	0.940	3
E19.1	Reduction in cost	159	4.72	0.737	0.939	4
E18.4	Waste of material after demolition of a portion of work	159	4.72	0.684	0.942	4
E18.1	Compensating waste of resources such as unnecessary increased project budget	159	4.72	0.657	0.949	4
E18.2	Waste due to uneconomic use of machines (machines lying idle on site)	159	4.70	0.612	0.942	5
E18.3	Material wastage due to incorrect decisions	159	4.67	0.689	0.937	6
E19.2	Waste reduction	159	4.67	0.743	0.944	6

4. 2 Exploratory Factor Analyses

Nine variation orders factors that contribute to wastage were subjected to exploratory factor analyses (EFA). Table 2 revealed the presence of correlation matrix of nine variables. All nine factors were less than one (<1) and were considered to be strong variables. Correlation co-efficient have been conducted to ensure visibility of co-efficient greater than 0.3 and there were quite a number of correlations greater than 0.3 tentatively suggests that the factor analysis was appropriate (Hooper, 2012).

Table 2. Variation order contributing to wastage

Correlation Matrix										
		E18.1	E18.2	E18.3	E18.4	E18.5	E18.6	E19.1	E19.2	E19.3
Corre	E18.1	1.000	0.735	0.703	0.529	0.538	0.557	0.504	0.492	0.561
	E18.2	0.735	1.000	0.896	0.666	0.689	0.612	0.618	0.561	0.637
	E18.3	0.703	0.896	1.000	0.788	0.790	0.712	0.718	0.651	0.695
	E18.4	0.529	0.666	0.788	1.000	0.929	0.765	0.639	0.552	0.592

lation	E18.5	0.538	0.689	0.790	0.929	1.000	0.825	0.691	0.620	0.656
	E18.6	0.557	0.612	0.712	0.765	0.825	1.000	0.622	0.518	0.579
	E19.1	0.504	0.618	0.718	0.639	0.691	0.622	1.000	0.893	0.926
	E19.2	0.492	0.561	0.651	0.552	0.620	0.518	0.893	1.000	0.879
	E19.3	0.561	0.637	0.695	0.592	0.656	0.579	0.926	0.879	1.000

Table 3 below represents the Kaiser-Meyer-Olkin (KMO) with the value of 0.867, which was beyond the anticipated value of 0.6 (Kaiser, 1960), and the Bartlett’s test of sphericity (Bartlett,1954) reached statistical significance of 0.000 ($p<0.05$), supporting the factorability of the correlation matrix with a degree of freedom of 36.

Table 3. Variation order contributing to wastage-KMO and Bartlett’s test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.867
Bartlett's Test of Sphericity	Approx. Chi-Square	1751.526
	df	36
	Sig.	0.000

Table 4 shows the anti-image matrix of correlation as a measure of sampling adequacy (MSA) which was beyond 0.5 as the indication of the factorability of the data set.

Table 4. Variation order contributing to wastage-anti image correlation

Anti-image Matrices									
Anti-image Correlation									
	E18.1	E18.2	E18.3	E18.4	E18.5	E18.6	E19.1	E19.2	E19.3
E18.1	.905[a]	-0.316	-0.092	-0.061	0.149	-0.233	0.214	-0.097	-0.203
E18.2	-0.316	.844[a]	-0.702	0.157	-0.144	0.125	0.073	0.116	-0.137
E18.3	-0.092	-0.702	.874[a]	-0.283	0.050	-0.116	-0.169	-0.093	0.110
E18.4	-0.061	0.157	-0.283	.842[a]	-0.761	0.089	-0.088	0.132	0.074
E18.5	0.149	-0.144	0.050	-0.761	.829[a]	-0.456	0.068	-0.163	-0.079
E18.6	-0.233	0.125	-0.116	0.089	-0.456	.903[a]	-0.183	0.182	0.053
E19.1	0.214	0.073	-0.169	-0.088	0.068	-0.183	.853[a]	-0.431	-0.626
E19.2	-0.097	0.116	-0.093	0.132	-0.163	0.182	-0.431	.905[a]	-0.269

E19.3	-0.203	-0.137	0.110	0.074	-0.079	0.053	-0.626	-0.269	.878[a]
a. Measures of Sampling Adequacy(MSA)									

Table 5 shows the communalities of the variables after extraction and were above the acceptable 0.3 value (Field, 2000).

Table 5. Variation order contributing to wastage- communalities

Communalities		
	Initial	Extraction
E18.1	0.598	0.473
E18.2	0.837	0.673
E18.3	0.887	0.838
E18.4	0.879	0.695
E18.5	0.908	0.775
E18.6	0.719	0.617
E19.1	0.905	0.734
E19.2	0.827	0.612
E19.3	0.885	0.706
Extraction Method: Principal Axis Factoring.		

Table 6 shows the total variance explained of the variation order factors that contribute to wastage on construction performance and it revealed one components which had eigenvalue of above 1 namely: (6.430). The components eigenvalues defined 71.448% of the total variance before the rotation and 68.045% after the rotation. The Kaiser eigen value which is greater than 1 was retained for interpretation (Fabrigar, et al. 1999). The total of nine variable were strengthen by a scree plot test (Pallant, 2013). The results indicated the variables which clearly defined the variation order factors contributing to wastage on construction performance.

Table 6. Variation order contributing to wastage- total variance explained

Total Variance Explained		
Factor	Initial Eigenvalues	Extraction Sums of Squared Loadings

	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**6.430**	71.448	**71.448**	6.124	68.045	68.045
2	0.978	10.865	82.313			
3	0.710	7.891	90.204			
4	0.333	3.696	93.900			
5	0.221	2.459	96.360			
6	0.123	1.364	97.723			
7	0.094	1.041	98.765			
8	0.059	0.657	99.422			
9	0.052	0.578	100.000			
Extraction Method: Principal Axis Factoring.						

Table 7 indicates the factor loading of the variation order factor contributing to wastage on construction performance. The total of nine variables loaded on one components, since only one factor was extracted the solution cannot be rotated any further. Moreover, the results were strengthened by a scree plot test below figure 1 (Pallant, 2013). The results indicated the variables which clearly defined the impact of variation order on construction performance.

Table 7. Variation order contributing to wastage- factor matrix

Factor Matrix[a]	
	Factor
	1
E18.3	0.915
E18.5	0.880
E19.1	0.857
E19.3	0.840
E18.4	0.834
E18.2	0.820

E18.6	0.786
E19.2	0.783
E18.1	0.688
Extraction Method: Principal Axis Factoring.	
a. 1 factors extracted. 4 iterations required.	
Rotated Factor Matrix[a]	a. Only one factor was extracted.
The solution cannot be rotated.	

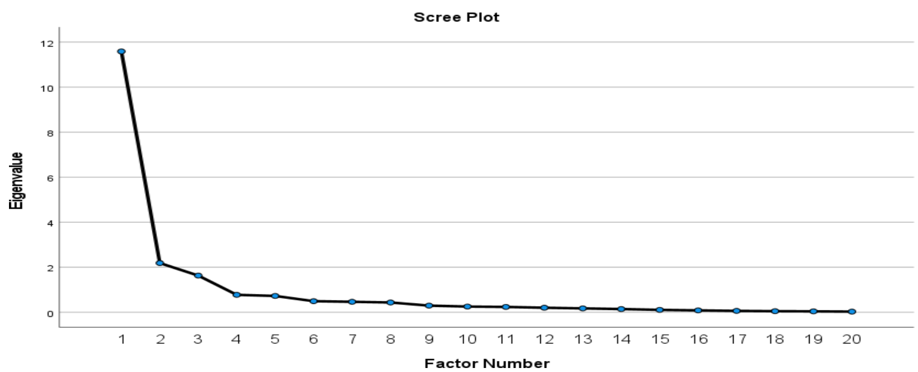

Figure 1. Scree plot for variation order contributing to wastage

4. 3 Validity of variation orders contributing to wastage

Principal component analysis (PCA) criteria were used to test the validity of the factors of variation orders that contribute to wastage. The observed variables were compensating waste of resources of which increased project budget unnecessarily; waste due to uneconomic use of machines (machines lying idle on site); material wastage due to incorrect decisions; waste of material after demolition of a portion of work; waste due to wrong use of material or wrongly specified; waste of time, which results in more labour charges. The factors showed a number of correlation greater than 0.3 which tentatively suggest factor analysis to be appropriate. Empirical reliabilities to determine the validity and reliability of the factors (Hooper, 2012).

5. Conclusion

Variation orders contribute to wastage on construction projects through compensating waste when material ordered for one specific purpose is used for another. For example, facing bricks ordered for external wall erection may be used for internal plastered walls due to change in specification. Furthermore, the waste due to the uneconomic use of plant arising when the plant lies idle on site as a result of a variation order. Moreover, waste of materials due to incorrect decision, inconsistent inspection of works by the project consultant, in addition, waste of materials after the demolition of a portion of work caused by the variation order to change trade. Therefore, good communication and planning must be key to all stakeholders involved in a construction project in reducing variation order. Planning has many phases the first phase is the most important phase, which is called the initial planning phase, which includes preliminary engineering and design. This phase has to take sufficient time to avoid changing inadequate order design. The planning and proper communication channels will reduce the occurrence of variation orders, improve productivity, improve safety, improve professional relations among stakeholders and will encourage the usage of limited resources wisely.

References

Alhilli, H.K and Rezoqi, S.I (2021), Investigating variation orders causes in Iraqi building construction projects, *E3S Web of Conference*s, 318: 1-9.

Arain, F.M and Low, S.P (2005). Strategic management of variation orders for institutional buildings: leveraging n information technology. *Project Management Institute*. 36(4): 27-41.

Bartlett, M.S. (1954). A note on the multiplying factors for various x approximations. J.R Statistics society, 16:296.

Bower, D., (2000). A systematic approach to the evaluation of indirect costs of contract variations. *Construction Management & Economics*, *18*(3):263-268.

Fabrigar, L.R., Wegener, D.T., MacCallum, R.C. and Strahan, E.J., 1999. Evaluating the use of exploratory factor analysis in psychological research. *Psychological methods*, *4*(3), p.272.

Field, A. (2000). Discovering Statistics using SPSS for Windows. London – Thousand Oaks – New Delhi: Sage publications.

Hooper, D., 2012. Exploratory factor analysis.

Kaiser, H.F., 1960. The application of electronic computers to factor analysis. *Educational and psychological measurement*, *20*(1), pp.141-151.

Khalifa, W and Mahamid, I. (2019). Causes of change orders in construction projects. *Engineering, technology and applied science research*, 9(6):4956-496.

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*, 23:285-294.

Love P.E. D., Ika, L. A., Ahiaga-Dagbui,D.D., Locatelli, G., and Sing, M.C. P., (2019) Make-or-break during production: shedding light on change-orders, rework and contractors margin in construction, Production Planning & Control, 30(4): 285-298.

Memon, A.H., Rahman, I.A and Hasan, F.A. (2014). Significant causes and effects of variation orders in construction projects. Research Journal of applied sciences, Engineering and Technology, 7(2):4494-4502.

Mohamed, A.A. (2001). Analysis and management of change orders for combined sewer over flow construction projects. *Dissertation*, Wayne State University.

Oladapo, A.A. (2007). A quantitative assessment of the cost and time impact of variation orders on construction projects, *Journal of Engineering, Design and Technology*, 5(1):35-48.

Osman, Z., Omran, A. and Foo, C.K., (2009). The potential effects of variation orders in construction projects. *Journal of Engineering*, *2*:.141-152.

Pallant, J., 2013. *SPSS survival manual*. McGraw-hill education (UK).