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Article

Causes of Variation Orders and Their Effect on Building Construction Projects

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Abstract: Variation order has been one of the serious issue that building construction industry has been battling with, the aim of this research are to identify factors that are responsible for this menace and to examine its effects on building construction project in southwestern Nigeria. Questionnaire method was used to extensively obtain the view of people, construction projects consultants, employers, contractor, tiller, carpenter, plumber, Iron bender, were consulted. The study was able to isolate more than seven causes of changes in order out of as many as 26 causes. Cost and time factor constituted the most visible consequences of variation orders in construction projects. These findings seem to agree with the view of experienced specialists. However, this research is restricted to building construction project, construction management problems is common within the developing countries, change of plans or scope by employer, error and omission in design, differing site conditions and contractor's financial difficulties were some of the critical factors causing variation order in building construction projects. Safety performance index, non-safety performance index and spearman rank correlation coefficient were used to carry out the analysis, generally, these result shows a low correlation between owner and the contractor while that of the employer and contractor is as high as 97%. It was observed that change of plans or scope by employer, error and omissions in design and owners' financial problems were the critical factors that cause the existence variation orders in building construction projects We hope that this work will give a sensitive clue towards reducing [if not totally eradicating] variation order by the owner, planner and executors of building construction projects in Nigeria.

Keywords: Variation order, building construction project, experienced specialist, project consultants and time factor.

1. Introduction

Variation order contains set of constructions which allow changes or modifications to be made to an earlier agreement in terms of volume or nature of take to be carried out O Brian (1988). The changes may be due to various reasons such as the modification of scope, schedule, cost, methods and time lag. Changing order from part of the major reason why contractors don't meet up with the time specified for completion of most contract work (Pourrostam and Ismail, 2011; Amu et.al, 2005). 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 building and civil surveying. A major factors necessitating variation order is attributable to preference or taste for enhanced finished product different from initially agreed quality by the owner in a particular contractual agreement.

Many research works have been carried out by expert in the construction industry on the effects of variation orders. According to Hsieh et.al (2004) (10-17) percentage ratio change order cost to total project cost is related to four metropolitan public works in Taiwan. It was shown by Ndiho Kubwayo and Haupt (2011) that 63% of site in structures culminated in additional works and he then suggest that more attention should be devoted to the design stage such that the issue of variation order can be minimized. They also showed that 14% of all site in structures are accompanied by wastages most especially those involving modifications to already completed works.

In addition, an investigation of the consequences of variation orders in an institutional building projects showed that 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 for most cases of inability to complete and handover projects work as agreed initially at the commencement of the work Chan and Yeong, (1995).

The focus is to investigate the cause of variation orders on building construction projects in southwestern Nigeria.

2. Methodology

In the developing countries like Nigeria, there have been a lot of adverse effects on ongoing building projects as a result of constant changed in the course of carrying out such projects. A comprehensive list of causes and consequences of variation orders was compiled from a review of previous works which comprise of documented observations, opinion and views of various specialist and experts of more than 20 years' experience in the field. The respondents were quantity surveyors, lecturers, directors, site managers and engineers. The experience of respondents in building 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 involve in one form or the other of administration of variation orders. The questionnaire was divided into three main parts; the first part requested for background information of the respondent while the second part focused on causes of variation order and the third part examined the effects of variation order in building construction projects. The overall analysis of the salient factors was determined by the evaluation of mean rank score through the use of statistical package for social science (SPSS).

The outcome as shown by responses monitored via a 5-point like Kant scale Vis –a –viz; strongly disagree =1; disagree = 2; Neutral= 3; Agree= 4; strongly agree = 5 indicated that construction works will always be subjected to the theory behind variation orders.

Causes of Variation Orders: Based on the previous study, 26 factors responsible for variation orders were identified and the data collected from the second part of questionnaire was analysed in table 1. The most 10 important mean work score were computed for each cause from the perspective of the employers, consultants and contractors score through SPSS (table 2).

Table 1: Causes of Variation orders in building construction projects

S/N	**Causes of variation orders in building construction project**
1	Owner's financial problems
2	Change of plan or scope by owner
3	Substitution of interval or proceedings
4	Design change originated by owner
5	Change in design by engineer or consultant
6	Conflict between contract documents
7	Error and omissions in design
8	The scope of work for the contractor not well defined
9	Value engineering
10	Technology change
11	The lack of coordinate between consultant and contractors

12	Differing site conditions
13	Contractors financial difficulties
14	The required equipment and tools are not available
15	The required labour skill are not available
16	Workmanship or material not meeting the specifications
17	Contractor desire to improve his financial condition
18	Previous construction delay by other contractor working on different contracts
19	Acceleration of work
20	Safety consideration
21	Weather condition
22	New government regulations
23	Demolition and rework
24	Strikes
25	Quantity improvement
26	Conflict in the project site

Based on table 2, change of plans or scope by the owner was identifies as the greatest cause of variation orders, this is followed by error and omission while both site condition and financial difficulties takes the third position based on ranking.

Spearman rank correlation coefficient was calculated according to formula (Assat and Al-Hajj; 2000).

$$R_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

where: R_s is the spearman rank correlations coefficient

d is the difference in ranking between the contractors and the consultants

n is the no of variation

The value of the spearman rank Correlation coefficient ranges from +1 (perfect correlation) 0(now correlation) to -1 (perfect negative condition). The results of the correlation between employer and consultant, employer and constructor as well as between consultant and contractor were 0.87, 0.99 and 0.91 respectively.

Generally, these results show a low correlation between the owner and the contractor while there is a good correlation between the employer and the contractor with 97% agreement.

Table 2: 10 most important mean ranks of causes of variation order in construction project

Causes of mean variation order	Rank employer	Mean employer	Rank consultant	Man consultant	Rank contractor	Overall contractor	Rank mean	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
Error and Omission 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

Effect of Variation orders	Rank employer	Mean employer	Rank consultant	Man consultant	Rank contractor	Overall 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
Dispute 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

3. Effect of Variation Order

The third part of the questionnaire examined the effects of variation orders in building 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 through the employer, consultant and contractors score 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 viewpoint thus ranking second and third respectively. The Spearman rank correlation coefficient was computed. 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 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).

4. Analysis and Discussion of Findings

A total of twenty seven (21) constructions sites were investigated. The data of twenty one sites (almost 78%) was found valid for the analysis.

The safety performance investigation performa was divided in four different categories covering various aspects of site safety measurement. These included (1) personal safety (2) housekeeping (3) scaffolding safety and (4) access to height. Each category had certain statements. Every statement was also supplied by various positions and ways to judge the level of safety non-performance of a particular aspect. The investigator had to mark the level of agreement to the statement on a scale defining level of safety non-performance with non-performance level increasing from a score 0 to 10.

4.1. Safety Performance Factor Analysis

A total of twenty five (25) safety performance factors were observed during the site investigation. Based on the level of safety non-performance, the Factor Non-Performance Index (FNPI) and the Factor Performance Index (FPI) were calculated using the following formulae. The indices for all factor are shown in Table 4.

$$\text{Factor Non-Performance Index (FNPI)} = \frac{\sum(factor\ score * no.\ of\ site\ at\ a\ particular\ score)}{(total\ no.\ of\ response\ for\ a\ factor * 10)}$$

Where “10” in the denominator indicates the score at the maximum level of safety non-performance.

Factor Performance Index (FPI) = 1- FPNI

On the basis of Factor Non-Performance Indices the top ten safety non-performance practices found on sites are as follows.

I. Ear defender not worn (while using noisy equipment)
II. Protective footwear not worn
III. Face mask not worn (in dusty conditions)
IV. Guardrails are missing on working scaffolds platforms

V. Safety helmets not worn

VI. Gloves not worn (while handling materials which have sharp edges, hot or cold cause skin problems)

VII. Openings left uncovered or unguarded

VIII. Goggles or other items of eye protector not worn (when using motorized cutting equipment, welding and cartridge operated tools)

IX. Timbers left lying around, have nails left in

X. Tools or small machinery not placed or stored properly.

Table 4: Factor Indices

Safety performance measurement factor	Factor non-performance index	Factor performance index
Safety protection category		
Safety helmets not worn	0.65	0.35
Protective footwear not worn	0.73	0.27
Gloves not worn (while handling materials which have sharp edges, hot or cold cause skin problems)	0.61	0.39
Ear defender not worn (while using noisy equipment)	0.88	0.16
Goggles or other items of eye protectors not worn (when using motorized cutting equipment, welding and cartridge operated tools)	0.51	0.49
Face masks not worn (in dusty conditions)	0.73	0.27
House Keeping Category		
Timbers left lying around, have nails left in	0.51	0.50
Opening left uncovered or unguarded	0.59	0.41
Stored materials are stacked/ store unsafely	0.30	0.70
Walkways, access routes and staircases are limited with rubbish/ debris	0.43	0.57
Proportions of operatives, who are working at heights, have seen throwing down objects	0.23	0.77
Tools or small machinery not placed or stored properly	0.49	0.52

Excavations not provided with safety mesh erected all around	0.37	0.63
Scaffolding Category		
Working scaffolds platforms missing boards	0.33	0.67
Scaffolds boards placed incorrectly, causing a 'trap'	0.36	0.64
Toe-boards missing on working scaffolds platforms	0.44	0.56
Guardrails are missing on working on working scaffolds platforms	0.69	0.31
Scaffolds/ formwork missing base-plates under the standards	0.33	0.67
Site personnel, who are working at heights, are climbing up or down the outside scaffolds	0.36	0.64
Access to Heights Category		
Ladders too short for the jobs	0.22	0.78
Ladders used without being tied or secured	0.33	0.67
Ladders used unsafely	0.24	0.76
Ladders placed with broken or defective rung	0.26	0.74
Mobile tower scaffolds used unsafely	0.28	0.72
Mobile work platforms (MWP) being used unsafely	0.40	0.60

Most of the safety non-performance practices belong to self-protection category. This shows that the site workers themselves are either unaware of the importance of personal safety practices or they do not want to wear protective gears and kits as they consider it as hindrance in their work productivity. Also, it was observed that the site management seemed non-interested in emphasizing the need of personal safety practices among their workers.

4.2. Safety Performance Category Analysis

Based on the factors non-performance and factors performance indices, the category Non-performance and the category performance indices of the four categories have been calculated with the following formulae. The indices are shown in Table 5.

Category Non-Performance Index (CNPI) = $\frac{\sum FNPI(\,of\ the\ factors\ in\ the\ category)}{No.\ of\ factors\ in\ the\ category}$

Category Performance Index (CPI) = $\frac{\sum FPI(\,of\ the\ factors\ in\ the\ category)}{No.\ of\ factors\ in\ the\ category}$

Table 5: Category Indices

Safety performance management category	CNPI	CPI
Self-Protection Category	0.69	0.31
House-keeping Category	0.42	0.58
Scaffolding Category	0.42	0.58
Access to Heights Category	0.29	0.71

Self-protection category has got the highest non-performance index (i.e. 0.69) that again supplements weakness identified in the self-protecting safety practices.

4.3. Safety Performance Index

The safety performance index of the twenty one sites investigated has been calculated. For this, firstly the safety non-performance score of each site has been calculated by summing up the scores of safety non-performance of all the factors for a site. Then the safety non-performance index have been calculated using the formula.

Safety non-performance index = $\frac{\sum(score\ of\ safety\ non-performance\ of\ all\ factors\ for\ a\ site)}{maximum\ score\ for\ a\ particular\ site}$

Where, maximum score for a particular site = No. of factors investigated x 10

Further, the Safety Performance Index (SPI) has been calculated using the following formula:

Safety Performance Index (SPI) = 1- Safety Performance Index

A construction firm's safety performance level has been assessed based on the percentage safety performance index (%SPI) using the criterion shown in Table 6.

Table 6: Safety Performance Level

% SPI	0-20%	>20%-40%	>40%-60%	>60%-80%	>80%-100%
Safety Performance Level	Extremely Unsafe (US)	Unsafe (US)	Moderately Unsafe (MUS)	Safe (S)	Extremely Safe (ES)

The summarized data for the 21 sites is shown in Table 7.

Table 7: Site Safety Performance Summary

Site No.	Safety Non-Performance Score	Safety Non-Performance Index	SPI	%SPI	Safety Performance Level
1	17	0.2	0.8	83.0	ES
2	46	0.2	0.8	81.6	ES
3	57	0.3	0.7	71.5	S
4	64	0.3	0.7	69.5	S
5	60	0.3	0.7	68.4	S
6	77	0.4	0.7	65.0	S
7	82	0.4	0.6	64.3	S
8	80	0.4	0.6	63.6	S
9	27	0.4	0.6	61.4	S
10	84	0.4	0.6	60.0	MUS
11	89	0.4	0.6	59.5	MUS
12	97	0.5	0.5	53.8	MUS
13	33	0.5	0.5	52.9	MUS
14	105	0.5	0.5	52.3	MUS
15	129	0.6	0.4	38.6	US
16	142	0.6	0.4	38.3	US
17	146	0.7	0.3	33.6	US
18	55	0.7	0.3	31.3	US
19	138	0.8	0.2	23.3	US
20	66	0.8	0.2	17.5	EUS
21	149	0.8	0.2	17.2	EUS

Results indicate that most of the companies lie in the range of extremely unsafe to moderately unsafe (about 58%) and the rest are in the safer range (42%). This shows that overall level of the industry as regard to the site safety needs drastic improvement. Safety seems to be on the less priority on the agenda even during the execution phase that is not a healthy trend. Statistical analysis of the safety performance indices of the twenty one sites is shown in the table 8.

Table 8: Statistical Analysis of Spi's

Mean	0.52
Standard error	0.04
Median	0.59
Standard Deviation	0.19
Sample Variance	0.39
Kurtosis	-0.78
Skewness	-0.44

The mean of SPI is 0.52 indicates that the overall safety performance of building construction organizations on work sites is only average. This is alarming finding and should be further diagnosed as to the causes of safety non-performance and improvement measures that can be adopted. One important highlight from the statistical analysis is that the kurtosis has come out to be a negative value (-0.78) which indicates the forming of a platycurtic curve. This indicates that the safety performance index data is very scattered, which in turn shows that the safety performance levels are not at

5. Conclusion and Recommendation

This Study which was conducted in the South Western Part of Nigeria has been able to isolate the causes and effects of variation orders in construction projects. The project under review in the current study was building construction project from 2001 to 2010. It was observed that change of plans or scope by employer, error and omissions in design and owners' financial problems were the critical factors that cause the existence variation orders in building construction projects. In addition, the result shows that time and cost overruns and disputes had great significant effects on project performance. It is to the advantage of this study that its application are very relevant not only in Nigeria building construction system but also in other developing countries construction industries. The following recommendations from the study are proposed in order to reduce [if not eradicating] 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 explanat4ions on each step of the project stage.

- Government policy must be formulated in such a way that the contractor and consultants will not be seen as constituting more to variation order.
- There must always be enlightenment program towards sensitizing all categories of workers involve in building construction project in order to minimize variation order that has always been an impediment to building construction project.

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