CAUSES AND EFFECTS OF DESIGN VARIATION IN ROAD CONSTRUCTION PROJECTS IN OGUN STATE

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Abstract

In Nigeria, studies have shown that majority of our roads are characterized with long cracks, potholes and other pavement defects, and these have posed serious challenges and disaster to both lives and properties of the citizens of the country. These, according to researchers are sometimes attributed to design variation in road construction. This study is aimed at identifying the causes and effect of design variations in road construction projects. The data used for this study were collected via well-structured questionnaires which were administered on all the sixty (60) construction professionals working in the ministry of housing Abeokuta Ogun state, Nigeria, using total enumeration sampling method. But, fifty of the retrieved questionnaires were deemed fit for the analysis of the study, representing 83% response rate. This study found out that design variation was mostly caused by unforeseen site conditions, inadequate scope of work for contractors and poor provision of safety considerations with corresponding mean score of 3.84, 3.72 and 3.62 respectively, and that the most prevalence effect of design variation in road construction project include poor quality of work, delay in project's completion and increase in project's cost with mean score of 3.89, 3.80 and 3.78 respectively. The study therefore concluded that design variations occur before, during and after road construction project and recommended that adequate pre-project planning and effective project management be carried out during road project design to reduce the effects of design variation in road construction project.

Keywords: Design Variation, Road Construction, Project

Introduction

Road transportation is very crucial as regard the development of every society and country. It dictates the pace of socioeconomic development in any country (Alhinai & Widyarto, 2020). It is worthy to note that no economy can thrive where there is no good road. However, roads play an important role in increasing the country's gross domestic product. There is a positive correlation between a country's economic growth and the standard of its road network. A country roads network should be designed and constructed in a systematic manner that the intended social cultural and the economic benefits can be maximized. It is of importance to highlight that Nigeria roads have often been characterized with long cracks, potholes and other pavement defects. These have posed serious challenges and disasters such that in Nigeria one can hardly travel a kilometer without coming across a long cracks and potholes (Karunakaran et.al., 2019). These had resulted to a hike in the number of road accidents and a plunge on the nation's economic development. Every single road built are often known to have a stipulated design life; but roads often times fail long before the planned expected date; some fail after construction, some after flooding while others last to its entire life expectancy with appropriate maintenance. These occurrences according to Olofinyo et.al., (2019) can sometimes be attributed to variation in road construction.

Variation is a change or any modification to the contractual guidance provided to the contractor by the owner or consultants (Ismail et.al., 2012). Variations include changes to plans, specifications or any other contract documents occur after the award of the initial contract or after work might have commenced. The changes may be due to various reasons such as inadequate design, change in design, and misinterpretation of drawings leading to construction error (Memon et.al.,2014). Meanwhile, variation is usually regularized by the issuance of a variation order and this made the variation orders to become part of the project's documents (Alaryan et al., 2014).

Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the ambit of the scope of the works without alteration of the original contract. Variation orders involve additions, omissions, alterations and substitutions in terms of quality, quantity and schedule of works. The benefits of road cannot be overemphasized for any serious government who prioritize the good economy as one of her agenda. This necessitated the Ogun state government to construct fifty four (54) new roads across the state in year 2021.The roads constructed include 29 in Ogun Central; 10 in Ogun West and 19 in Ogun East (Https://www.thisdaylives.com).

Similarly, Ogun State government has on 20th November, 2021 approved the construction of new set of roads measuring over 42.7km across the state (Https://www.thenationnews.com).

A clause permitting variation of works is an essential feature of any construction contract because without it, the contractor is not bound to execute additional work or to make omissions or changes. Under contractual provisions, the client has the right to vary the extent and the nature of the performance to be rendered by the contractor. Furthermore, the contractor could not refuse to carry out the varied obligation with the only remedy being an adjustment of price to be paid for the performance, and in appropriate circumstances, an extension of time in which to execute such performance. The spirit in which variation orders are permitted allows the contract to proceed without compiling another contract to cater for the changes (Cabahug et.al., 2018). Muhammad et al., (2015) noted three prominent sources of variation as following: design error and omission account for 65% of variation; design changes account for 30% of variation, and other reasons account for only 5% of variation. To buttress this position, Kassa (2020) affirmed that variation has a 65% likelihood of being caused by design error. Therefore, it can be argued that there is a strong connection between design error and variation. It is on this basis that this study investigates the causes of design variation, its effects, and solutions in road construction projects.

Unfortunately, because construction projects involve complex operations which cannot be accurately determined in advance, variation orders occur. Arguably, variation orders cannot be avoided completely. The presence of variation clauses in contracts amounts to admitting that no project can be completed without changes. Even if carefully planned, it is likely that there will be changes to the scope of the contract as the work progresses. Various authors concluded that variation orders are common to all types of projects (Khair et.al., 2018). It is hardly possible to complete a construction project without changes to the plans or the construction process itself due to the complexity of construction activities. Variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, discrepancies between contract documents.

While variation orders are common in construction projects, an improved understanding would require their categorization into their root or origin agents and causes. The cognizance of origin agent consists of the identification of the initiator of the variation orders. A study that focused on the point of view of developers of potential causes of variation orders was conducted by Etikan et.al., (2016), and four main origin agents of variation orders were identified. These included "client", "consultant", "contractors" and "others". There is an interrelation between the origin agent and causes of variation orders.

Various reasons account for the inherency of variation orders on a project. These according to researchers are enlisted in the Table below:

No	**Needs for design variations**	**Client**	**Consultant**	**Contractor**	**Others**
1	Change in plans or scope	o			
2	Change in schedule	o			
3	Client's financial problems	o		o	
4	Inadequate project objectives	o			
5	Impediment in prompt decision making process	o			
6	Obstinate nature of the client	o	o	o	
7	Replacement of materials or procedures	o			
8	Change in specification	o	o		
9	Change in design consultant		o		
10	Errors and omissions in design		o		

11	Conflicts between contract documents		o		
12	Inadequate scope of the contractor		o		
13	Technology change		o		
14	Value engineering		o		
15	Lack of coordination		o		
16	Design complexity		o	o	
17	Inadequate working drawing details		o		
18	Inadequate shop drawing details		o		
19	Consultant's lack of judgment and experience		o	o	
20	Consultant's lack of required data		o		
21	Ambiguous design details		o		
22	Non-complaint design with government regulations		o		
23	Lack of contractor's involvement in design			o	
24	Unavailability of equipment			o	
25	Unavailability of skills			o	
26	Contractor's desired profitability			o	
27	Differing site conditions			o	
28	Defective workmanship			o	
29	Fast track construction			o	
30	Poor procurement process			o	
31	Lack of communication			o	
32	Long lead procurement			o	
33	Lack of strategic planning			o	
34	Weather conditions				o
35	Change in economic conditions				o
36	Change in government regulations				o
37	Socio-cultural factors				o
38	Unforeseen problems				o

Source: Etikan, Musa, and Alkassim, (2016)

The study is limited to Ogun State due to the proximity of the researchers to the source of data required for the study. Ogun State is a state in Southwestern Nigeria, created by the Murtala/Obasanjo administration on the 3rd of February, 1976 from the old Western State. Ogun State borders Lagos State to the South, Oyo State and Osun State to the North, Ondo State and the Republic of Benin to the West. Abeokuta is both Ogun State's capital and most populous city; other important cities in the state include Ijebu Ode, the former royal capital of the Ijebu Kingdom, and Sagamu, Nigeria's leading kola nut grower. Ogun State had a total population of 3,751,140 residents as at 2006.



Plate 1.1: Map of Nigeria showing Ogun State.

Source: www.researchgate.net

1 METHODOLOGY

This study adopted descriptive survey techniques and quantitative research design using numerical data to identify statistical relationship between the variables. The populations for the study were Sixty (60) construction professionals in the Ministry of Works, Oke-Mosan, Abeokuta, Ogun State. Primary data were sourced from the professionals through well–structured questionnaire administered to the construction professionals in the Ministry of Works Abeokuta, Ogun State. A total of fifty (50) questionnaires were retrieved and valid for the analysis of the study. The questions were structured to collect information on the identified factors causing design variation and its effect on road construction projects in Ogun State, Nigeria. The questionnaires were ranked on 5-points Likert Scale (1= very low, 2= low, 3= neutral, 4= high 5= very high). Data collected were analyzed using Statistical Packages for Social Science (SPSS) version 16 and presented using percentage and mean item score.

3. Results

Demographic Information of the Respondents

Table 1: Profession of Respondent

Profession	Frequency	Percentage	Valid Percent	Cumulative Percent Valid
Civil Engineer	22	40.0	40.0	44.0
Architect	13	26.0	26.0	70.0
Quantity Surveyor	10	20.0	20.0	90.0
Builders	5	10.0	10.0	100.0
Total	50	100.0	100.0	

Source: Field Survey (2021)

The professions of the respondents as shown in Table 1 reveals that 44% (22) of the respondents are Civil Engineers, 26% (13) are Architects, 20% (10) are Quantity Surveyor, while 10% (5) are Builders. The distribution shows that the built industry professionals were adequately represented.

Table 2: Academic Qualifications of the Respondents

Qualification	Frequency	Percentage	Valid Percent	Cumulative Percent Valid
HND	17	34.0	34.0	34.0
BSc	23	46.0	46.0	80.0
MSc/M.Tech	10	20.0	20.0	100.0
PhD	0	0.0	0.0	100.0
Total	50	100.0	100.0	

Source: Field Survey (2021)

Table 2 shows the academic qualifications of the respondents with holders of Bachelor of Science (B.Sc) degree in their respective fields represents 46% (23), 34% (17) possess HND certificate, 20% ((10) hold a Master of Science/Technology (M.Sc/M. Tech) degree certificate. None of the respondents hold a Doctor of Philosophy certificate.

Table 3: Years of Experience of the Respondents

Year of Experience	Frequency	Percentage	Valid Percent	Cumulative Percent Valid
Below 5 years	6	12.0	12.0	12.0
6-10 years	29	58.0	58.0	70.0
11-15 years	12	24.0	24.0	94.0
Above 15 years	3	6.0	6.0	100.0
Total	50	100.0	100.0	

Source: Field Survey (2021)

Table 3 shows the distribution of the respondents based on the years of professional experience reveals that 12%(6) of the respondents have below 5 years of professional experience, 58%(29) have between 6-10years of professional experience, 24%(12) have between 11-15 years of professional experience while 6% (3) of the respondents have above 15 years of professional experience. It could be deduced from Table 3 that the respondents are experienced enough to provide relevant answers to the questions in the questionnaire.

Table 4: Causes of Variation in Road Construction Project

Causes of Variation	N	Minimum	Maximum	Mean	Rank
Unforeseen site conditions	50	2	4	3.84	1
Inadequate scope of work for contractor	50	3	4	3.72	2
Safety consideration	50	2	4	3.62	3
Conflicts between contract documents	50	2	4	3.58	4
Errors and omissions in design	50	1	4	3.14	5
Valid N	50				

Source: Field Survey (2021)

As indicated in Table 4, 'Unforeseen site conditions, Inadequate scope of work for contractors, and Provision of safety consideration' with respective mean score of 3.84, 3.72 and 3.62 are the major causes of design variation in road construction works.

Table 5: Effect of Design Variation in Road Construction Project

Effect of Variation	N	Minimum	Maximum	Mean	Rank
Poor quality of work	50	2	4	3.89	1
Delay in project's completion	50	3	4	3.80	2
Increase in project's cost	50	2	4	3.78	3
Demolition and rework	50	2	4	3.55	4
Dispute among stakeholders	50	1	4	3.10	5

Valid N	50

Source: Field Survey (2021)

Table 5 shows that, most prevalent effect of design variation in road projects as identified by the respondents were poor quality of work, delay in project's completion and increase in project's cost with respective mean score of 3.89, 3.80 and 3.78.

Table 6: Mitigating measures to design variation in road construction project

Mitigating Measures	N	Minimum	Maximum	Mean	Rank
Pre-Project Planning	50	2	4	3.74	1
Effective Project Management	50	3	4	3.70	2
Visitation to site before designing	50	2	4	3.69	3
Clients to give more time for designing	50	2	4	3.51	4
Paying attention to project's details	50	1	4	3.12	5
Use of computer softwares	50	2	4	2.98	6
Knowledge sharing	50	2	4	2.84	7
Valid N	50				

Source: Field Survey (2021)

Table 6 revealed pre-project planning and effective project management with mean score of 3.74 and 3.70 as the major mitigating measures to eliminate or minimize the effect of design variation on road construction project.

4. Discussion

Study by Khair *et al.* (2018) affirmed that the complete elimination of variation on construction project seems to be very impossible and stated that changes in scope of contract frequently occur as the work progresses and concluded that variation on project is inherent due to some reasons ranging from finance, design, aesthetic, geographical among others. This is relatively in tune with this study as the study also concluded that variation is part and parcel of the project, with an exception identified by this study which sreveled unforeseen site conditions and inadequate scope of work as the major causes of design variation on road construction projects. Muhammed *et al.* (2015) and Kassa (2020) also identified design error, omissions and design changes to account for over 65% of variation in road projects which agrees with the findings of the study.

Similarly, Memon *et.al* (2014) opined that causes of variation include inadequate design, changes in design and misinterpretation of drawings. This contradicts the conclusion of this study which had unforeseen site conditions as the most predominant causes of design variations on road construction project.

The most prevalent effect of design variation in road projects as identified in the study were poor quality of work, delay in project's completion and increase in project's cost. This corroborates in part, the assertion of Olofinyo *et al.* (2019) that roads often times fail long before the planned expected date; some fail after construction without achieving life expectancy and this was attributed to poor quality of work and lack of appropriate maintenance. The study therefore identified pre-project planning and effective project management as measures to mitigate or minimize the effect of design variation in the road construction projects.

5. Conclusion

The research established that design variations occur before, during and after road construction project. It was concluded that the most prevalent cause of design variation is the "unforeseen site condition". This occurrence was

found to affect the quality of work and therefore, pre-project planning was suggested as a way of preventing the adverse effect of design variation in road construction projects.

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