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Research paper



A study of quality performance and deviations in public building in Bauchi State of Nigeria

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Abstract

The construction industry occupies an important position in the Nigerian economy and contributes massively to her socio - economic improvement, while a building quality is one of the important measures of success in the construction industry. This essence of this paper is to evaluate the various factors affecting quality performance in public building construction projects; by comparing consultants and contractor perception of the factors affecting quality performance and to ascertain origins and scale of quality deviation in the design and construction phase of public building in Bauchi State. 125 questionnaires were administered to the study population through stratified random sampling technique, 64 consultants and 38 contractors responded indicating a response rate of 81.6%. Data were analyzed using Mean Item Score and Mann-Whitney U-test. The study identified: use of unskilled labour; poor on-site supervision; the experience and competence of supervising team as key variable affecting quality performance. The study indicated that there is no significant difference between consultant and contractors perceptions on the factors affecting quality performance in public building in Bauchi State and lastly by analyzing fifteen building construction projects files at completion the figures indicate that 83.05% of deviations had it root from design and 16.95% had it root from construction.

Keywords: *Construction Projects; Quality Deviation; Quality Performance; Quality Management; Quality Performance*.

1. Introduction

Construction operation is the concluding phase of the three phase process that creates the physical form which satisfies the conception and permits the realization of a design, while the project design phase translates the primary concept into an expression of a spatial form that will satisfy the client's requirement in an optimum economic manner [1]. According to [2] achieving quality is one of the ultimate goals of all participants in construction projects. Quality in the construction industry tends to be defined as "the ability of products and processes to conform to the established requirements" while the quality of construction project is predominantly determined during the design and construction phases of the project [3]. It is also defined as the entirety of features and characteristics of production process that bear on its ability and capacity to fulfill the stated requirement [4].
According to [5] the term deviation indicates that a product or result does not completely fit in to all specification necessities and this does not necessarily constitute an outright failure. The main causes of quality deviation are generally identified during the undertaking of these project phases. This means corrective actions made in these stages of the project will have a significant influence on the quality of the project's product. Quality deviations in construction have long become a debatable subject among the diverse participants involved in construction projects. Yet, only a few formal studies analyzing its causes and effects have being done. This paper is essentially to appraise the various factors affecting quality performance in building construction project; compare consultants and contractor perception these factors and to find the causes and scale of quality deviation in building projects in Bauchi State at design and execution phase.

2. Literature review

The contribution of the construction industry to the socio- economic development most countries are huge. The construction industry occupies a significant position in the Nigerian economy. In 2008, it contributed 1.3% to the GDP while in 2013 it was 3.1% [6]). The Nigerian Construction Industry(NCI) ability to provide vital infrastructure has made it a prime driver of economic growth [7]. The industry is also a provider of jobs for professionals such as architects quantity surveyors and building engineer. As well as to main contractors, sub-contractors, nominated suppliers and labourer who are engaged by these contractors. The NCI today is bedeviled with numerous problems and quality performance is one of them due to the complicated nature of operation and project supervision by non-technical personel. As a result the contruction industry requires that quality of projects are taken more seriously in construction project, since quality nowadays has become an essential factor in determining success. .

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2.1. Quality in construction

Researchers have identified various quality factors in construction [5,8 - 15]. In this paper, twenty – nine (29) factors from related literature were grouped into eight key factors categories as shown in Figure 1 and are disscussed below. These will also form the basis for the survey of professional describe later.



Fig. 1: Factor Influencing Quality in Construction.

2.2. Design

The creation of architectural plan, engineering drawing and circuit drawings etc is known as design. In construction, the project design phase is the translation of the primary concept into an expression of a spatial form that will satisfy the client's requirement in an optimum economic way. However, designers sometimes do not met clients' requirement due to either lack of experience and knowledge of the designer or unclear owner's requirement for design [16]. Quality factors under this category: experience and knowledge of consultants; unclear clients brief; conformance to codes and standards; detailed drawing and specifications and inadequacy of contract document

2.3. Labour

In construction productivity normally refers to labour productivity which is defined as a unit of work produced per man-hour. According to [17] fast-tracking an activity or multiple activities in order to reduce the overall duration of a project impacts on quality of work on construction site. Factor under this category: use of unskilled labour; low wages for labourer; lack of motivation; inadequate apprentice training.

2.4. Material

Construction materials comprise bricks aggregate, cement, steel etc. this are the basic building material which decides the strength of a building. If poor quality materials are used, then the overall strength of the building will be compromised. According to [18] material is the most important factor in explaining seismic behavior of buildings. Quality factors under this category: poor material and plant management; prices of material.

2.5. Quality schemes

The impact of defects from both a client and contractor viewpoint proves that quality can be very critical in shaping the success of both the project and the status of the contractor. Some design professionals believe that quality is measured by the aesthetics of the facilities they design; whereas from a construction company viewpoint quality means sustaining the quality of construction works at the required standard so as to obtain customer's satisfaction that would bring durable competitiveness and business survival for the companies [19]. According to [20] it is importmant to implement standard quality procedures in construction either in terms of quality assurance(QA) or quality control(QC). Since quality is perceived in different ways by stakeholders. Factor include:poor planning and schedulling;lack of quality control and assurace system; poor safety and health program.

2.6. Equipment

Construction equipment's are one of the key factors for improving contractors' capability in performing their work more efficiently and effectively. Construction equipment's require huge amount of capital resources to acquire them. However, through the utilization of construction equipment, extensive volume of work can be completed in a shorter period of time or within the project schedules [21]. Quality factors under this category: availability of equipment, machine operator skill; use of incorrect equipment

2.7. Site personnel

Quality work begins with the conscious effort of contractor to achieve the specification of the contract and this can only be attained by compliance of the site staff to workmanship standards. The failure of building structures are due to workmanship negligence and the lack of effort put into quality control processes on construction site. According to [11] lack of experience and competency of labour are the causes for low quality workmanship produced by contractors on construction site. Quality factors under this category: project manager's inexperience and lack of knowledge; poor on-site supervision; experience and competence of supervising team.

2.8. Owner

The significance of the owner role originates at the start of the project as plans are formulated. At this stage, the owner has the utmost influence over the construction process. It is important for the project owner to recognize that no two projects are exactly alike because there will be variation in scope of work and its monetary value. Therefore, the active involvement of the owner has major impact on the safety and quality performance of all contractors on site [22]. Quality factors under this category: client funding, design changes; delay of interim payment and delay in decision making.

2.9. Contractor

Contractors have two primary objectives on a construction project; to complete for the owner, a service that is satisfactory and on time and to make a profit. Contractors transform the plans and specification prepared by the architect/engineer into a physical structure. The contractor manages the work of the craftsmen, sub-contractors and suppliers and take responsibility of completing project for the agreed upon terms; because the quality of work provided by his workforce affects the quality of the project and the performance of the main contractor [23]. Quality factors under this category: conformity to specification; experience and competence of contractor; sub-contractor supervision; improper personnel allocation to job and number of projects at hand.

3. Research methodology

3.1. Study area

Bauchi is a State located in North –Eastern Nigeria, created form the former North-Eastern state in 1976. The state has 20 Local Government Areas with a total land area of 49,119 Sq.km representing 5.3% of Nigeria. The state is characterized by alternate rainy and dry season; the rainfall ranges from 1300mm per annum in the south and only 700mm in the extreme north. The state is situated amid latitudes 9^0 3' and 12^0 3' north and longitude 8^0 50' and 11^0 east [24]. Figure 2 shows the map of Bauchi State.



Fig. 2: Map of Bauchi State , Nigeria.

3.2. Sample size

The representativeness of any sample is uncertain, if there is no survey of the population. However, representativeness can be computed statistically [25]. In estimating the sample size for this study, the formula for determining the sample size of unlimited population was used

$$SS = \frac{Z^2 \times P \times (1 - P)}{C^2} \quad (1)$$

Where, SS = Sample Size.
Z = Z Value (e.g. 1.96 for 95% confidence interval).
P = Percentage picking a choice, expressed as decimal, (0.50 used for sample size needed).
C = Confidence interval (0.05)

$$SS = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{.05^2} = 384 \quad (2)$$

Correction for finite population

$$SS\ new = \frac{SS}{1 + \frac{SS - 1}{pop}} \quad (3)$$

Where 'pop'= population
When population is 90, then

$$SS\ new = \frac{384}{1 + \frac{384 - 1}{90}} = 73 \quad (4)$$

It means 73 questionnaires are to be distributed to consultants.

Similarly, for Contractors

$$SS\ new = \frac{384}{1 + \frac{384 - 1}{60}} = 52 \quad (5)$$

It means 73 questionnaires are to be distributed to contractors

3.3. Method of data collection

A structured questionnaire was designed and was used as the data collecting tool. The questionnaire tool comprised two parts including demographic background and also research variables. Each factor quality were designed using Likert scale structured to five scaling, that is, 1=Strongly Disagree (SD); 2=Disagree (D); 3=Neutral (N); 4=Agree (A); and 5=Strongly Agree (SA). Questionnaires administration to study population was through stratified random sampling technique.
To ensure an impartial representation of the two distinct categories of respondents for the study, sampling technique was adopted. To achieve the third objective; a pilot study was conducted on projects completed from 2012 to 2017, to identify the contractors who executed the projects and the consultants involved because dependable data from which a theoretical population frame can be obtained was not available. The study adopted 15 building projects executed by 12 contractors as population frame; because these projects provide complete data set meeting the requirement of the study. For a meaningful comparison, only projects of category C of classification building project by Federal Government of Nigeria [26] as shown in Table 1 were considered.

Table 1: Classification of Building Projects

Category	CLASSIFICATION
A (N1 - N5million)	Small
B (N15 - N50 million)	Medium
C (Over N50million)	Large

The projects were further sub - classified according to the following types based on [27].

- "New construction – the design and construction of the structure only recently produced or developed.
- Upgrade Construction – the design and construction associated with the modification of an existing facility.
- Rehabilitation Construction – the design and construction associated with the normalization of an existing facility after a long period of dilapidation.

3.4. Data analysis

Statistical Package for Social Sciences (SPSS) version 22 was used to conduct Mann-Whitney (U) test on data were collected on an ordinal scale. Mann-Whitney test is the nonparametric alternate to t test [28], [29] and Mean Item Score (MIS). MIS equals total score divided by the number of respondents for every factor and was also to rank the order of importance of highlighted variables in conjunction with Standard Deviation. MIS = 3.0 was the cut – off mark to decide the importance of the weight of the factors (MIS ≥ 3.0 implies factor having significant effect and MIS < 3.0 implies factor having insignificant effect. This is consistent with the approach adopted in related previous studies [30]. The second objective was achieved through document analysis. It involved analyzing each project file under the groupings shown in Table 2.

Table 2: Groupings Used for Classifying Project Data

Deviation	Brief Description
Construction change	Change in the method of construction
Construction error	Error made during construction
Construction omission	Omission made during construction
Design change/improvement	Design revision, modification, and improvements
Design change/construction	Design change initiated by construction
Design change/site	Design change required due to site condition
Design change/Owner	Design change initiated by owner
Design error	Error made during design
Design omission	Omission made during design

4. Finding and discussion

102 appropriately completed questionnaires out of 125 questionnaires administered were returned. This comprised of 64 consultants and 38 contractors; indicating a response rate of 81.6% and questionnaires were distributed by stratified random sampling technique. The factors affecting quality performance in public building in Bauchi state are as indicated in Table 3. The five major factors affecting quality performance in public building in the study area are use of unskilled labour; poor on-site supervision; experience and competence of supervising team; inadequate apprentice training and improper allocation of personnel to job. Furthermore, low values of standard deviation, indicating level of reliability in respondents' response.

Objective two of the study was to compare the opinions of consultants and contractors for or against factors affecting quality performance of public building in the area of study. The research hypothesis for this purpose was: Ho: There is no substantial difference between consultant and contractors' opinions on the factors affecting quality performance in public building in Bauchi State. The hypothesis test result is obtainable in Table 4 and it indicates that consultant's and contractor's opinions on the factors affecting quality performance in public building in Bauchi State are statistically the same since the probability value (p) is not less than or equal to 0.05, therefore the result is not significant. This, therefore, implies that views of consultant and constrictors are not statistically different.

For the third objective, since project size varied based on total cost, analysis of the data was based on deviations numbers. To achieve this, a comparison of amount of deviations was all done on a percentage base to let assessments among the projects. Table 5 shows percentage of the total amount of deviation in design and construction for respective project. Design change largely stemmed from design change/owner and design change/improvement.

Table 3: Factors Affecting Quality Performance in Public Building in Bauchi State

Factors	N	MIS	Std. Deviation
Use of unskilled labour	102	4.2745	.56563
Poor on-site supervision	102	4.2353	.92465
Experience and competence of Supervising team	102	4.1765	.99913
Inadequate apprentice training	102	4.1667	.98587
Improper allocation of personnel to job	102	4.1569	1.02199
Conformity to specification	102	4.1471	.96879
Poor planning and scheduling	101	4.0594	.94680
Lack of Motivation	102	4.0196	1.06223
Project Manager ignorance and lack of knowledge	102	3.9608	.94315
Use of improper equipment	102	3.9510	.81298
Experience and Competence of contractor	102	3.8431	.87592
Lack of Quality Control and Assurance system	98	3.7857	1.01788
Prices of materials	102	3.6569	.96979
Availability of Machine	100	3.6400	.94836
Sub-contractor supervision	100	3.6300	1.02154
Unclear Client Brief	102	3.5392	1.23217
Low wages of labourer	100	3.4900	1.02981
Lack of detailed drawing and specification	102	3.4510	1.01110
Delay in decision making	101	3.4158	1.04180
Poor safety and health program	101	3.3663	1.11106
Poor Material and plant management	102	3.2843	.84873
Delay of Interim Payment	102	3.1569	1.24872
Design changes	102	3.0098	1.13883
Number of projects at hand	102	2.9608	1.18507
Conformance to codes and Standards	102	2.9608	1.18507
Experience and knowledge of consultants	102	2.9608	1.18507
Client funding	102	2.8431	1.03163
Inadequacy in Contract documents	102	2.7353	1.04291
Machine operator skill	102	2.6961	1.01268

Table 4: Mann – Whitney (U) Test for Difference in Consultants and Contractor Opinions on the Factors affecting Quality Performance in Public Buildings

Parameter Test	N	U-value	Z-value	P-value	Decision
There is no significant difference between consultants and contractor's perception on factors affecting quality performance in public building in the study area	58	420.500	0.000	1.000	Accepted

Table 5: Number of Design / Construction Deviation as % of Entire Number of Deviation for Respective Project

CSP					Deviation Category						
	CC	CO	C E	Total	DC/I	DC/C	DC/S	DC/W	D E	D O	Total
CS 01	15.40	10.00	3.20	28.60	16.10	1.00	9.60	24.10	10.20	10.40	71.40
CS 02	7.30	6.40	1.50	15.20	15.80	5.00	11.00	23.80	10.40	18.80	84.80
CS 03	13.50	0.00	10.70	24.20	24.00	2.80	10.00	22.00	7.30	9.70	75.80
CS 04	4.30	4.70	5.20	14.20	18.10	2.30	1.10	36.10	18.50	9.70	85.80
CS 05	0.00	8.90	0.00	8.90	18.00	3.30	2.70.	26.40	26.10	14.60	91.10
CS 06	8.30	8.10	4.70	21.10	17.00	2.80	2.90	24.10	26.40	5.70	78.90
CS 07	16.10	7.80	5.80	29.70	28.00	0.00	0.00	33.30	0.00	9.00	70.30
CS 08	8.30	6.00	6.50	20.80	24.30	4.80	0.00	32.30	8.30	9.50	79.20
CS 09	0.00	0.00	19.00	19.00	47.00	0.00	9.00	25.00	0.00	0.00	81.00
CS 10	5.00	9.50	3.50	18.00	28.20	4.00	0.00	31.00	13.40	5.40	82.00
CS 11	0.00	0.00	6.50	6.50	25.00	0.00	20.00	34.50	4.00	10.00	93.50
CS 12	7.30	6.45	4.75	18.50	17.00	0.50	11.00	23.80	10.40	18.80	81.50
CS 13	0.00	0.00	0.00	0.00	24.00	2.80	0.00	36.20	27.30	9.70	100.00
CS 14	16.00	3.50	0.00	19.50	36.00	12.30	0.00	26.10	6.10	0.00	80.50
CS 15	0.00	0.00	10.00	10.00	28.00	3.30	2.70.	27.90	26.10	2.00	90.00
Average	6.77	4.76	5.42	16.95	24.43	2.99	5.33	28.44	12.97	8.89	83.05

Legend :CSP- Case Study Project; CC- Construction Change; CO - Construction Omission; CE - Construction Error ; DCI –Design Change/Improvement ;DCC – Design Change / Construction ; DCS – Design Change / Site ; DCW – Design Change /Owner ; DE - Design Error ; DO – Design Omission

Table 6: Magnitude of Deviation as % of Deviation for Respective Project

Case Study Projects	Deviation	
	Design	Construction
CSP 01	71.40	28.60
CSP 02	84.80	15.20
CSP 03	75.80	24.20
CSP 04	85.80	14.20
CSP 05	91.10	8.90
CSP 06	78.90	21.10
CSP 07	70.30	29.70
CSP 08	79.20	20.80
CSP 09	81.00	19.00
CSP 10	82.00	18.00
CSP 11	93.50	6.50
CSP 12	81.50	18.5
CSP 13	100.00	0.00
CSP 14	80.50	19.50
CSP 15	90.00	10.00
Average	83.05	16.95

The magnitude of deviation in design and construction are as shown in Table 6. The highest number of deviation occurred in design accounting for 83.05 % on the average for the amount of deviation on the projects whereas construction deviations range from 00.00 – 29.70% of the entire amount of deviations.

4.1. Effect of types of construction

An assessment of percentage of the whole number of deviations for the type of construction (new, upgrade and rehabilitation) in the study was done as shown in Figure 3; the results indicate higher deviation figures in the design change/improvement category for upgrade construction project than new and rehabilitation construction. The higher average is not unexpected since upgrade project are mostly concerned with the development and enhancement of operational services, amenities or facilities.

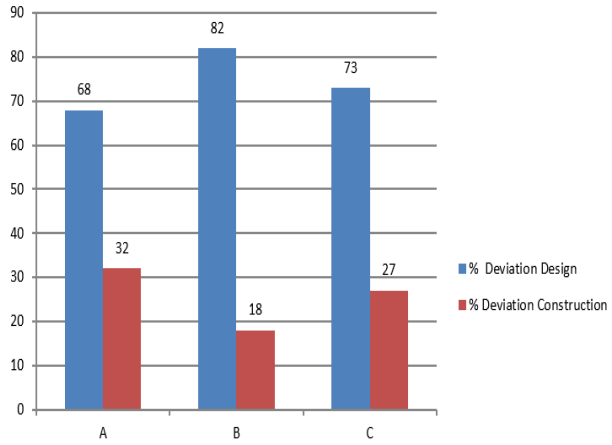


Figure 3 : Deviation for Type of Construction

4.2. Discussion of findings

The major factors affecting performance of public building project in Bauchi State are related to use of unskilled labour, poor on-site supervision, experience and competence of supervising team, inadequate apprentice training and improper allocation of personnel to jobs. The least important factors are number of projects at hand, conformance to codes and standards, experience and knowledge of consultants, client funding, and inadequacy in contract document and machine operator skill. These findings are not in agreement with that of [14] that identified conformance to code and standards, selection of contractor and financial issues as key factors affecting quality. On the other hand studies by [15] and [13] are in agreement with the study, they observed that experience and sound qualification of personnel play a role in a professional act leading to better performance of quality, time, cost, productivity and safety of the project. According to [11]) lack of experience and competency of labour are the causes for low quality workmanship, this is in line with the finding of this study. As regards quality deviation in design and construction, discussion with project representatives' revealed government agencies or procuring entities initiated most design change in order to reduce total construction cost because of the limited resources accruing to the them nowadays; this ensures that building projects are done with budget.

Furthermore, even though construction deviation impacted less than design deviation to the total project cost; the study found out that the percentage of construction deviation was largely due to contractor's unethical practice; whereby they change construction method in order to make more gain.

5. Conclusion

The study concluded that quality is an essential feature for project sustainability and owner happiness. Construction cost is very high; this means it is imperative to ensure quality of the completed project. This study findings identified the main factors affect quality during the construction, phase to include use of unskilled labour, poor on-site supervision, experience and competence of supervising team, inadequate apprentice training and improper allocation of personnel to jobs. The least important factors are number of projects at hand, conformance to codes and standards, experience and knowledge of consultants, client funding, and inadequacy in contract document and machine operator skill. Further analysis indicates design deviation average 83.05% of the total number of deviation; while design change/owner accounted for 28.44%; whereas on the whole construction deviation accounted for 16.95% of the entire deviations.
To conclude this study categorized past data for analysis to identify the type and prevalence of deviations. The study recommends this procedure for application to future construction projects to identify probable area of deviations so that necessary action to reduce them will be taken.

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