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# Development of a Framework for Ensuring Quality in Highway Construction Projects

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***Abstract****: This study develops a framework for ensuring quality in highway construction projects. Over the years, there have been some factors supposedly affecting highway construction quality in Nigeria. The conditions of the roads in four case study areas in Nigeria were examined. 100 road construction practitioners within the four case study areas participated in a quantitative survey and data obtained was subjected to relative importance index (RII) analysis. Factors affecting project quality were ranked in order of very high significance factors (RII > 0.8), high significant factors (RII 0.6 – 0.8) and low significant factors (RII < 0.6). The study tested the interrelationships between the attributes of project quality which were performance, reliability and aesthetics, and the attributes of customer satisfaction measured through contractor re-patronage and referral. Findings and analysis from their views proved that the construction projects in Nigeria are not up to quality standard as these case study projects were subjected to quality analysis. This stresses the need for the adoption of a framework for enhancing project quality and customer satisfaction within government road construction projects in Nigeria. This study also presents recommendations to ensure quality construction projects in Nigeria.*

**Keywords—**framework; highway construction; relative importance; project quality.

## 1. INTRODUCTION

The construction industry plays a vital role in the economy. It is also complex in its nature because it comprises large numbers of parties as owners (clients), contractors, consultants, stakeholders, and regulators. Despite this complexity, the industry plays a major role in the development and achievement of society's goals.

Quality has become a very popular subject in recent years due to conceptual changes in the industry. Quality and quality systems are topics which have been receiving increasing attention worldwide. The product in any industry should be manufactured to a required standard, one that provides customer satisfaction and value for money. Therefore, a finished and acceptable project should be able to meet the required quality and design standard, provide customer's satisfaction and value for money. Quality is an essential element for sustainability and customer satisfaction. In construction projects, quality performance is considered vital for client satisfaction. The need for achieving quality of the finished product in highway construction is very important.

Quality management plan in construction can be described as a tool that guides construction professionals on the proper execution of construction projects in terms of quality. Quality management in construction is a distinct feature that needs to be given utmost seriousness in any construction work. It is a holistic approach to managing a project, and ensures effort to achieve and improve on the required standard for a project which is well planned and organized, so as to obtain customer's satisfaction, provide value for money, and ensure fitness for purpose.

Now, quality in construction industry can be defined as the attainment of acceptable levels of performance from construction activities. This performance would be attained when the activity meets or exceeds the requirement of the client or the owner. The quality of any product or service is achieved when it conforms to the desired specifications. In other words, the quality of a construction project is the totality of its attributes that enables it to perform a stated task or to fulfill a given need for an acceptable period of time. According to Dada, Obiegbu and Kunya (2016), quality management covers all activities of integrating all processes, procedures, structures and products to achieve quality in the finished project.

Council of Registered Builders of Nigeria captured quality as the critical factor in evaluating the success or otherwise of construction project delivery, which provides the measurable parameter for appreciating the extent to which the expectations of project participants are acceptably fulfilled. In a nutshell, quality by Agbenyega (2014) is aimed at standardization, while Bala, Keftin, and Adamu (2012) perceived quality management as a wide-scale failure prevention program.

The reasons for the underperformance of highway construction projects in terms of quality were studied to suggest possible remedial measures. Surveys and research carried out have identified some attributes responsible to impact quality performance of the projects. Statistical analysis of questionnaire responses based on these attributes resulted into two distinct sets of success and failure attributes. Further analyses of individual sets of success attributes and failure attributes separately grouped them into fewer critical success and failure factors. The factors that adversely affected the quality performances of projects or failure attributes are according to Oluyemi-Ayibiowu et al. (2019) as follows: Inadequate construction planning and scheduling of construction projects, conflict among project participants, hostile socio-economic environment, harsh climatic condition, lack of adherence to project design, Project

Manager's ignorance and lack of knowledge and faulty project conceptualization. Analyses also led to the conclusion that the extent of contribution of various success factors varies with the current performance ratings of the project.

In the modern construction market, quality is a major function in construction organization. Achieving quality in construction industry has been a problem due to negligence from key construction players. The inefficient or non-usage of quality management procedures will result in poor quality construction projects. This study provides insight into areas that need improvements in developing a framework to ensure quality in highway construction projects. In addition, this study makes contributions to academic literature on quality in highway construction based on its findings.

## 2. RESEARCH METHODOLOGY

### 2.1 Case Studies

For the purpose of this project, four highway construction projects namely two completed projects and two ongoing projects were selected. The completed projects were used as case studies to review the history of quality achieved thus far in the construction industry, while the ongoing projects serve as a means to know the present state of quality management and procedures in Nigeria. The two completed projects are Construction of the third mainland bridge in Lagos and the construction of an interchange/fly-over bridge across Lagos-Benin expressway at Ore while the two ongoing projects are the dualization and re-construction of an 8.315km road from A-division to Ijoka and the construction of Oba (sir) Adesoji Aderemi East by-pass highway project.

*2.1.1* Construction *of the third main land bridge in Lagos State*

The Third Mainland Bridge comprises eight lanes of traffic with four lanes in each direction. There's a median separator (a structure to mark the division between the two sets of lanes) running down the center. Engineers used two slender concrete shafts or pillars for each of the bridge's piers. The project team constructed most of the bridge's spans at 45m, though some were up to 60m. The overall width of the structure is 33.1m, including 3.5m for the median separator. Engineers constructed an artificial island in Lagos Lagoon at the point where the bridge met the road interchange at Ebute Metta. The scheme used reinforced concrete to construct the main bridge. The structure's deck (the part that carries traffic) was also made of reinforced concrete.

*2.1.2 Construction of interchange/fly-over bridge across Lagos-Benin expressway*

This road project is situated in Ore, Ondo state. Over time, the existing road constituted an eye-sore because it was in a dilapidated state. It had been laden with potholes and so many bad sections thereby, causing accidents and loss of lives. Many road users even preferred to ply other routes even if it took longer to reach their destinations. These reasons and many more led to the proposed construction of an interchange/fly-over bridge and general rehabilitation of the road. The construction project spans across a length of 1.5km and the road has varying widths of 8m, 10m, 12m and 13m. Craneburg Construction Company under the supervision of REYOG Consultants, completed the road project by constructing a fashionable edifice in the area.

*2.1.3 Dualization and re-construction of an 8.315km road from A-Division to Ijoka*

The On-going project is located in Akure, Ondo State. The road was formerly a single carriageway separating outgoing/incoming traffic with the use of road markings. The road dualization project has a length of 8315m (8.315km), 2.7km dual carriageway and 5.3km single carriageway. It also has standard facilities such as 1.5km walkway on both sides, 1m width New Jersey median fitted with street lights, 600mm x 750mm drains, 150mm lateritic sub-base course, 150mm stone base course and 90mm asphaltic surfacing.

*2.1.4 Construction of Oba (sir) Adesoji Aderemi East By-Pass highway project*

The ongoing project is located in Osogbo, Osun state. The project was commissioned by the Rauf Aregbesola led administration in 2017 but this phase of the project was fully set in motion by Gov. Gboyega Oyetola for its completion. The ongoing project spans across a distance of 17.5km. This road project handled by Messrs SlavaYeditepe is a circumferential highway starting from the roundabout on Iwo Road, passing through Ofatedo to Ataoja Grammar School, through Ilesha Road and ending at Osogbo township stadium roundabout. The highway has four bridges, two of which has been completed successfully. The pavement of the highway is 7m wide, 3.5m on both sides separated by the median. The project duration is scheduled to be 12 months.

### 2.2 Nature, Types and Sources of Data

Purposive sampling method was adopted for this study. It is also known as deliberate sampling or non-probability sampling. This sampling method involves the purposive or deliberate selection of particular units of the population for constituting a sample that represents the population. Primary data were collated through structured questionnaire administered to construction professionals in construction companies in Nigeria. However, out of 130 copies of questionnaires administered, 100 responses were retrieved, processed and analysed. Proper review of past research efforts was conducted (via internet, print and online articles, reports that cover Nigeria and foreign publications) in order to obtain

secondary data. Analyses tool adopted for this study include: percentile, pie chat, mean item scores, and Relative Importance Index (RII).

### 2.3 Questionnaire Design

The questionnaire comprised of three key sections. The first section captures demographic information about the survey participants. The second section deals with the respondent's knowledge and involvement in quality management practices. The questions were based on mostly five-point scales from 1 to 5, corresponding to 'Not very important', 'Not important', 'Moderately important', 'Important' and 'Very important' respectively. The third section elicited the participant's perceptions of the factors affecting quality management practice within the construction industry. The responses were measured on a five-point scale from 1 to 5, corresponding to 'Strongly Disagree', 'Disagree' 'Neutral', 'Agree', and 'Strongly Agree' as shown in Table 1.

**Table 1**: Likert Scale Showing Ratings

| Item | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| Description | Not very important | Not important | Moderately important | Important | Very important |
| Scale | 1 | 2 | 3 | 4 | 5 |

### 2.4 Relative Importance Index (RII)

Relative importance index was used in the study to rank the factors affecting quality management and also practices that conform to quality management in the various building construction firms which ensures effective service delivery.

The Relative Importance Index (R.I.I.) formula is given as:

$$\mathbf{RII} = \frac{5n5 + 4n4 + 3n3 + 2n2 + 1n1}{A \times N}$$

where n5 - no of respondents with very important
n4 - no of respondents with important
n3 - no of respondents with moderately important
n2 - no of respondents with not important
n1 - no of respondents with not very important
A - Highest likert weight i.e., 5
N - Number of respondents

The Severity Index (I) was calculated to interpret the degree of severity effect of the identified factors influencing quality on highway construction projects using the Akure – Ilesha expressway and the Oba (sir) Adesoji Aderemi East by-pass highway project as case studies in Nigeria. This index was calculated as follows:

Severity Index (I) = **R. I. I** × **100**%

The severity index was categorized into five levels as follows:

- 0-49% was categorized as non-severe
- 50-69% was categorized as fairly severe
- 70-74% was categorized as moderately severe
- 75-79% was categorized as severe and
- 80-100% was categorized as most severe.

## 3. RESULTS AND DISCUSSION

### 3.1 Questionnaire Response

In order to achieve the objectives of this research, 130 questionnaires were administered to construction firms within the case study areas which are the Akure-Ilesha expressway and the Oba (Sir) Adesoji Aderemi highway project. Table 2 shows how the questionnaires were distributed and the responses.

**Table 2:** Questionnaire Distribution and Responses from the selected case studies

| Characteristics of Respondents Data | | | | | |
|---|---|---|---|---|---|
| | Akure-Ilesha | Oba Aderemi | A-Division | 3rd Mainland | Total |
| Number Distributed | 35 | 30 | 35 | 30 | 130 |
| Number of responses | 25 | 25 | 25 | 25 | 100 |

#### *3.1.1 General Information of Respondents*

Figure 1 shows that 43% of the respondents are engineers, 11% of respondents are project managers, 20% of respondents are architects, 15% are Land surveyors and 11% are quantity surveyors. Table 3 shows the summary of the characteristics of the respondents.

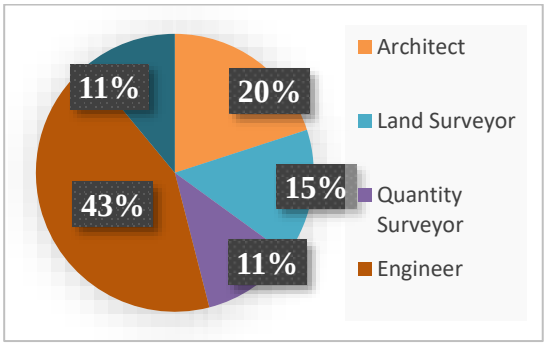


**Figure 1:** Categories of operation of respondents

**Table 3:** Summary of Characteristics of Respondents

| RESPONDENTS' DEMOGRAGHY | | | |
|---|---|---|---|
| **Category** | **Classification** | **Frequency** | **Percent (%)** |
| **Roles/position of respondents** | Architects | 20 | 20 |
| | Land Surveyor | 15 | 15 |
| | Quantity surveyor | 11 | 11 |
| | Engineer | 43 | 43 |
| | Project manager | 11 | 11 |
| | Total | 100 | 100 |
| | | | |
| **Respondent's designation** | Government body | 30 | 30 |
| | Contractor | 25 | 25 |
| | Customer/user | 40 | 40 |
| | Client (private) | 5 | 5 |
| | Funding body | 0 | 0 |
| | | | |
| **Level of Experience** | 0 -5 years | 33 | 33 |
| | 6 - 10 years | 37 | 37 |
| | 10 - 20 years | 19 | 19 |
| | > 20 years | 11 | 11 |
| | | | |
| **Road Classification** | Federal Trunk A | 50 | 50 |
| | State Trunk B | 50 | 50 |
| | Local govt. C | 0 | 0 |
| **Project Type** | New road | 50 | 50 |
| | Rehabilitation | 0 | 0 |
| | Maintenance | 50 | 50 |
| | | | |
| **Road Length** | < 1km | 0 | 0 |
| | 1 - 5km | 0 | 0 |
| | 6 - 10km | 50 | 50 |
| | > 10km | 50 | 50 |

### 3.2 Ranking Analysis (Relative Importance Index and Severity Index)

*3.2.1 Lagos – Benin Express Way Fly Over Bridge Road Project Analytical Data*

Table 4 shows the factors affecting project quality. The highest ranked factors with values of RII ≥ 0.80, regarded as factors with very high significance to project quality are Contractors' inability to meet their wage obligations to employees and Unrealistic project cost which were both ranked 1st with relative importance index (RII) of 0.856. Insufficient quality control plan having a relative importance index (RII) of 0.848 was ranked second. Accelerated construction by the contractor due to unsafe working environment and Lack of effective quality policy implementation both ranked third (RII 0.84). Based on the above results, it can be seen that Contractors' inability to meet their wage obligations to employees, unrealistic project cost and time and lack of effective quality policies and quality control programmes are key challenging factors affecting project quality in construction firms.

**Table 4:** Ranking of Factors affecting Project Quality for Lagos – Benin Expressway

| S/N | Statement | Average mean | RII | Severity | Rank |
|---|---|---|---|---|---|
| | Poor project performance can be attributed to: | | | | |
| 1 | Contractors' inability to meet their wage obligations to employees | 4.28 | 0.856 | 85.6 | 1 |
| 2 | Unrealistic project cost | 4.28 | 0.856 | 85.6 | 1 |
| 3 | Insufficient quality control plan | 4.24 | 0.848 | 84.8 | 2 |
| 4 | Accelerated construction by the contractor due to unsafe working environment | 4.2 | 0.84 | 84 | 3 |
| 5 | Lack of effective quality policy implementation | 4.2 | 0.84 | 84 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Lack of proper inspection at every construction stage | 4.16 | 0.832 | 83.2 | 4 |
| 7 | Bribery and corruption | 4.08 | 0.816 | 81.6 | 5 |
| 8 | Lack of construction quality control inspection programme | 4.04 | 0.808 | 80.8 | 6 |
| 9 | Project abandonment due to low cash flow | 4 | 0.8 | 80 | 7 |
| 10 | Unrealistic project time | 4 | 0.8 | 80 | 7 |
| 11 | Construction delays due to inefficient handling of materials | 3.92 | 0.784 | 78.4 | 8 |
| 12 | Poor communication among design and construction team | 3.88 | 0.776 | 77.6 | 9 |
| 13 | Client's inability to make scheduled payments to contractors | 3.84 | 0.768 | 76.8 | 10 |
| 14 | Non-compliance to Quality control | 3.8 | 0.76 | 76 | 11 |
| 15 | Lack of adequate supervision | 3.8 | 0.76 | 76 | 11 |
| 16 | Incessant project abandonment and restarting | 3.76 | 0.752 | 75.2 | 12 |
| 17 | Award of contract to unqualified contractor | 3.76 | 0.752 | 75.2 | 12 |
| 18 | Inadequate technical knowledge | 3.72 | 0.744 | 74.4 | 13 |
| 19 | Inadequate and poor coordination of project resources | 3.64 | 0.728 | 72.8 | 14 |
| 20 | Project abandonment due to design failure | 3.6 | 0.72 | 72 | 15 |

*3.2.2 Oba (Sir) Adesoji Aderemi East By-Pass Highway Project Analytical Data*

In a manner similar to the calculations carried out in Table 4, the factors affecting project quality were also ranked accordingly Oba (Sir) Adesoji Aderemi East By-Pass Highway Project. Based on the ranking, the contractors' inability to meet their wage obligations to employees is ranked 1st with relative importance index (RII) of 0.848, while Construction delays due to inefficient handling of materials and Lack of effective quality policy implementation both having a relative importance index (RII) of 0.84 are ranked 2nd, Unrealistic project time and Poor communication among design and construction teams are both ranked third (RII = 0.832). Therefore, it can be seen that Contractors' inability to meet their wage obligations to employees and Construction delays due to inefficient handling of materials are key challenging factors affecting project quality in construction firms.

*3.2.3 A-Division to Ijoka Dualization Project Analytical Data*

In a manner similar to the calculations carried out in Table 4, the factors affecting project quality were also ranked accordingly for A-Division to Ijoka Dualization Project. Based on the ranking, construction delays due to inefficient handling of materials, Contractors' inability to meet their wage obligations to employees, and Lack of construction quality control inspection programme and Lack of effective quality policy implementation are highly significant to project quality. These factors share a relative importance index (RII) of 0.848 while Inadequate and poor coordination of project resources is ranked last (RII = 0.712).

*3.2.4 The Third Main Land Bridge Analytical Data*

In a manner similar to the calculations carried out in Table 4, the factors affecting project quality were also ranked accordingly for the Third Main Land Bridge Project. Based on the ranking, Unrealistic project cost, Insufficient quality control plan, contractors' inability to meet their wage obligations to employees, accelerated construction by the contractor due to unsafe working environment, lack of effective quality policy implementation, Lack of proper inspection at every construction stage, Project abandonment due to low cash flow, Bribery and corruption, Unrealistic project time and Lack of construction quality control

inspection programme are high significance factors having RII values above 0.8. Project abandonment due to design failure was ranked last (RII = 0.72).

### 3.3 Quality Management Framework

*3.3.1 Dependent Variables*

In this research three variables of project quality were selected and investigated. They included project performance, project reliability and project aesthetics. The questionnaire design entailed a Likert scale which had a range of 1 for strongly disagree, 2 for disagree, 3 for indifferent, 4 for agree and 5 for strongly agree. With the adoption of a positivist paradigm, which holds that a quantitative research method should be employed to obtain data, the data obtained should be analysed statistically and provide answers to questions that bother on how much or to what extent a high importance was placed on items that the respondents either agreed or strongly agreed with.

Through the Relative Importance Index (RII), the ranking of the variables of project quality (Performance, Reliability and Aesthetics) to customer satisfaction (Contractor re-patronage and referral) were determined. Consequently, employing the ideology of the activity syntax box, the analogies expressed above, and drawing inferences from the Relative Importance index analysis, a revised conceptual framework was developed and presented in figure 2.

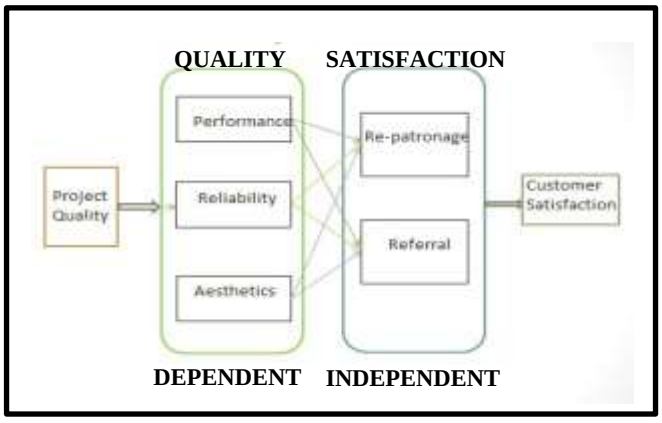


Figure 2: The proposed conceptual framework

*3.3.2 Independent Variables*

*A. Contractor Re-patronage*

Within the Nigerian construction industry, contractor re-patronage is seen as a yardstick for measuring satisfaction (Pritchard *et al.*, 2009 and Idoro, 2010). Stemming from the hospitality and sales sectors, employing the use of feedback mechanisms usually inform clients on the efficiency of contractors and could determine their re-use for carrying out services. Although the current construction practices advocate equality and fairness and conformation to the '*due process*' in allocation of construction jobs (which include a bid and tender process made available to all interested firms), satisfaction from previous construction activities can also be identified and measured through feedback or post-project evaluations as well as the choice of a particular contractor based on previous records.

*B. Contractor Referral*

In order to establish, measure, and develop ways of meeting or exceeding customer expectations, several researches have been carried out and diverse models formulated in various sectors and they are identified herewith. Owing to the fact that the construction customer has a higher influence on a construction project post-execution, the knowledge of customer expectation can only fully be rated on the completion of the construction project. Satisfaction from a constructed project can thus be estimated from the customers' rating of the contractors who delivered the road construction project.

In conclusion, the framework proposed in figure 3.2 shows the relationship between the dependent (Quality) and independent (Satisfaction) variables. Consequently, a situation whereby a construction contractor is given referral based on previous work carried out or re-patronized by a client as a result of past excellent construction practice would be an indication of the level of satisfaction obtained from the constructed project. In the course of this research, two attributes of customer satisfaction were adopted as they give a wholesome representation of construction satisfaction, especially from the perspective of the customer or road users.

## 4. CONCLUSION

Based on the results from the analysis of factors affecting project quality, the following were concluded about the project case-studies:

- LAGOS - BENIN EXPRESSWAY FLY-OVER BRIDGE ROAD PROJECT:

From the respondents' view, it was concluded that, project quality in the case study area is optimized when Customers (road users) prefer quality to cost. This factor is highly significant to the project's performance because it had a severity index value of 86.4%. Project quality is also optimized when construction site personnel work in teams and when the finished project seemingly meets the design specifications.

- OBA (SIR) ADESOJI ADEREMI EAST BY-PASS HIGHWAY PROJECT:

From the respondents' view and ranking of factors pertaining to project performance, Customers (road users) prefer quality to cost, Construction site personnel work in teams, The government body which awards a contract prefers quality to cost and the client (government) determines the project design

are high significant factors affecting project quality. Their severity index values range from 80% to 100%.

- A-DIVISION TO IJOKA DUALIZATION PROJECT:

From the respondents' view, it was concluded that Construction site personnel work in teams, Customers (road users) prefer quality to cost and the government body which awards a contract prefers quality to cost are the critical factors affecting project quality in relation to project performance. Their severity index values range between 80% and 88.8%.

- THE THIRD MAINLAND BRIDGE:

From the respondents' view, it was concluded that, project quality in the case study area is optimized when Customers (road users) prefer quality to cost and when construction site personnel work in teams. These factors are highly significant to project's performance because they have severity index values between 80% and 84%. Also, differences about quality between the government (client) and the contractors need to be adequately resolved to ensure that construction projects attain quality.

## 5. RECOMMENDATIONS

Based on the results of the analysis carried out, the following recommendations were made to provide some direction for improvement as follows:

- Total Quality Management (TQM) practices namely Quality assurance, Quality planning, Quality Control and Quality Improvement should be adopted by Nigerian construction firms.
- Nigerian construction industry needs to invest more in the education and training of employees on quality management systems and health, safety and environment (HSE) practices.
- Construction firms need to ensure all employees in charge of supervision on site are adequately qualified for such positions and these firms should also embark on frequent quality appraisal of their projects.
- Conformity of road design and specifications to world class standards should be ensured and adequate sanctions should be imposed on the non-compliance of quality by the Standard Assurance Organization.
- All project participants should recognize that implementing proper quality management will give them both a competitive advantage and also improve their collective reputation. Meeting clients' requirements the first time and every time within the complex processes of construction activities is achievable with right quality management practices**.**
- The construction industry should implement quality control inspection programs and quality policies.
- It is also suggested that further studies should be carried out in order to develop models based on the variables identified in this research work.

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