Rework in the Nigerian Road Construction Projects: Prevention rather than Remediation

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Abstract

Rework is a significant factor contributing to both time and cost overruns in construction project delivery processes. It has been observed that rework costs in building and engineering projects range from 5% to 20% of the contract value, leading to adverse implications in various sectors such as road construction, commercial buildings, and industrial buildings. This study is aimed at identifying the main causes of rework in road construction projects in Nigeria. Quantitative research was conducted using a structured questionnaire distributed to professionals in the Nigerian Construction Industry. Out of the 98 questionnaires distributed to Quantity Surveyors, Land Surveyors, Services Engineers, and Civil Engineers, 71 valid responses were analyzed, representing a 72% response rate. The data analysis involved calculating the importance index of various factors and conducting an analysis of variance (ANOVA). The findings revealed that factors such as pressure to finalize work, scope definition, lack of design audits, inadequate training, misinterpretation due to knowledge gaps, omissions of checks, and incorrect information distribution were the primary contributors to rework in road construction projects. Interestingly, the one-way ANOVA showed no significant difference in opinions among respondents from different professional backgrounds within the Nigerian Construction Industry. By pinpointing these causes of rework and considering professional perspectives, this study offers valuable insights for mitigating rework challenges in Nigerian road construction projects. It emphasizes the need for proactive measures to address these causes, prevent rework, and enhance overall project efficiency.

Keywords: Rework, Road Construction, Importance Index, Ranking, ANOVA

INTRODUCTION

Rework has long been recognized as a persistent challenge in the global Construction Industry (Hao & Goh, 2014; Ye *et al*., 2015; Forcada *et al*., 2017). It significantly affects the performance of construction and engineering projects (Love *et al*., 2016; Wanberg *et al*., 2013). Love (2002) states that, on average, rework contributes to 52% of the total increase in costs and can lead to time overruns of 22%. The costs of rework in building and engineering projects range from 5% to 20% of the contract value, with design scope changes accounting for up to 50% of rework occurrences (Barber *et al*., 2000; Love & Edwards, 2004).

Chan and Kumaraswamy (1997) and Love (2002) have identified rework as a major contributor to both cost and time overruns in construction project delivery processes. The Construction Industry Institute (2001) defines rework as "activities that need to be repeated on-site or activities that remove previously installed work as part of the project." Koskela (1993) further

emphasizes that rework in construction processes is wasteful because it stems from inefficiency, leading to the excessive use of human and construction resources beyond the initial estimate. Rework can occur at any stage of a project, whether it is during the design phase or the construction phase, and it may manifest as variations, non-variations, design errors, or omissions.

Similarly, Jaafari *et al*. (1994) have highlighted the various implications of rework in road construction, commercial buildings, and industrial buildings. However, Hwang *et al*. (2009) found that rework is more commonly observed in projects with a cost range between $50 million and $100 million, rather than in projects with costs exceeding $100 million. They further noted that larger projects tend to have lower costs associated with quality failures. Barber *et al*. (2000) and Love *et al*. (2012) have attributed cost overruns in transportation infrastructure projects, such as road construction, to errors and the need to redo work that was initially done incorrectly. This prevalence of rework poses a significant challenge in construction and engineering projects (Love 2002; Dissanayake *et al*. 2003; Love, Edwards 2004; Fayek *et al*. 2004; Palaneeswaran *et al*. 2008; Hwang *et al*. 2009; Zhang *et al*. 2012).

Moreover, related studies (Ye *et al*. 2014; Love *et al*. 2002, 2010; Love and Edwards 2004) have identified managerial aspects as key factors contributing to rework. Owner changes and design errors are considered root causes of rework, with a relatively higher cost impact compared to other factors (Hwang *et al*. 2009, 2014; Love and Edwards 2013). Design inconsistencies and reliance on IT application output under tight design schedules are also identified as major rework factors (Love *et al*. 2009). Rework often arises from design changes, errors, and omissions that stem from scope uncertainty and the chosen contracting strategy (Burati *et al*. 1992; Love *et al*. 2011).

Uncertainty within transportation infrastructure projects can complicate their planning, especially when information is scarce, leading to erroneous decisions during the early stages of a project (Alessandri *et al*. 2004). In the absence of sufficient knowledge, decisions made before or during construction may be incorrect and result in disastrous consequences (Love *et al*. 2012). High levels of uncertainty often lead to changes in initial drawings and specifications, forcing the project team to solve problems as they arise during construction. Such changes can be perceived as ambiguous and may lead to disagreements between parties (Williamson 1979). Regenerate response

Despite the detrimental consequences of rework in the Nigerian Construction Industry, particularly in road construction projects, there is a lack of comprehensive studies investigating its causes and costs. Existing research primarily focuses on the types, costs, and effects of rework in building construction, with little attention given to understanding the causes of rework in road construction projects. Therefore, the objective of this study is to identify the most significant causes of rework in road construction projects in Nigeria. By doing so, this research aims to contribute to the mitigation of rework in the Nigerian Construction Industry and globally, providing valuable insights for containing and reducing its occurrence.

RESEARCH METHODS

A systematic quantitative research approach was adopted for this study, utilizing a structured questionnaire administered to professionals in the Nigerian Construction Industry. The questionnaire aimed to gather information on the severe causes of rework in Nigerian road construction projects. The questionnaire consisted of two parts: Part A, which included five questions designed to collect information about the respondents, and Part B, which comprised

twenty-seven questions divided into three sub-categories: project, organization, and people (POP). This categorization followed the taxonomy of rework causes proposed by Love *et al*. (2012) and the research conducted by Forcada *et al*. (2014).

In section B of the questionnaire, each question presented respondents with five options on a Likert Scale to indicate the impact level of each cause on rework: 1 (Severe impact), 2 (High impact), 3 (Moderate impact), 4 (Little impact), and 5 (No impact). The questions were designed to assess the perceived impact of each cause on rework. Respondents evaluated the twenty-seven well-organized questions based on their objective judgment, indicating their chosen response for each cause.

The population of this study included all Construction Industry professionals working in both contractor and client organizations located in Abuja and Kaduna states of Nigeria. A purposive sampling procedure was employed, where questionnaires were distributed to any willing personnel. In total, 98 questionnaires were distributed among the respondents, consisting of 13 Quantity Surveyors, 25 Land Surveyors, 23 Services Engineers, and 37 Civil Engineers. Out of these, 71 questionnaires were successfully retrieved, representing a response rate of 72%. These 71 questionnaires were considered valid and used for the analysis in this study.

The collected data were analyzed by calculating the importance index of factors using the following formula:

Importance Index (%) = Σ a (n/N) x 100/5   1

> Where;
> a = is the constant expressing weighting given to each response
> n = is the frequency of the responses
> N = is total number of responses

RESULTS AND DISCUSSION

Average years of Respondents Work Experience
The chart below illustrates the distribution of work experience among the respondents. The survey included a total of seventy-one (71) participants. The analysis revealed that (11.3%) of the respondents had 0 to 5 years of experience, (21.1%) had 6 to 10 years of experience, (29.6%) fell within the 11 to 15 years category, (14.1%) had 16 to 20 years of experience, and 17 respondents (23.9%) had over 20 years of experience in construction work. This distribution of responses demonstrates the reliability of the data, as it was collected from individuals with varying levels of experience, spanning from lower to higher experience personnel.

Causes of Rework in Road Construction
A total of twenty-seven (27) variables were identified and incorporated into the questionnaire based on a comprehensive review of previous studies conducted by Love *et al*. (2012) on the taxonomy of rework causes and Forcada *et al*. (2014). These variables were considered to be potential causes of rework in construction projects. Section B of the questionnaire was dedicated to capturing data related to these variables. The collected data were subsequently analyzed and the results are presented in tables 1, 2, 3, 4, and 5.

The ranking of the causes of rework in road construction projects was based on the importance index values derived from the respondents' responses. The purpose was to identify the "project-specific causes" of rework that were considered more severe than others. According to the

respondents, the top three causes of rework in this category were pressure to finalize work, scope definition, and pressure to start execution, ranked as 1st, 2nd, and 3rd, respectively. This indicates that the respondents perceived these factors to have the most significant impact on rework. They reported experiencing intense pressure from clients or their representatives to complete projects, even when they had been granted formal extensions of time due to unavoidable circumstances or within the agreed scheduled completion period.

Table 1: Project Specific Rework Causes

Group A (Project)		
S/N Rework Causes	Importance Index	Ranking
1 Scope definition	73.71	2nd
2 Inappropriate Design	71.22	4th
3 No information about the Site	56.77	8th
4 Wrong materials selection	68.98	6th
5 Pressure to start execution	72.11	3rd
6 Pressure to finalize works	78.53	1st
7 Commencement of works before design is completed	62.65	7th
8 Inadequate management interface between contractors and consultants	52.87	10th
9 Discrepancies between admin and management team	51.34	11th
10 Poor Supervision	69.77	5th
11 Lack of adherence to quality control	53.65	9th
12 Lack of construction knowledge	50.33	12th

Table 2: Organizational Specific Rework Causes

Group B (Organization)		
S/N Rework Causes	Importance Index	Ranking
1 Lack of communication	54.87	7th
2 Lack of knowledge management	66.11	6th
3 Lack of design audits	76.33	1st
4 Lack of planning of resources	66.21	5th
5 Lack of staff supervision	73.76	2nd
6 Inadequate skills and knowledge	51.98	8th
7 Inadequate coordination with other projects	50.11	9th
8 Inadequate training	71.33	3rd
9 Ineffective implementation of quality assurance	70.76	4th

In the category of "organization-specific causes" of rework in road construction projects, lack of design audits, lack of staff supervision, and inadequate training were ranked 1st, 2nd, and 3rd, respectively, with importance index values of 76.33, 73.76, and 71.33. According to the respondents, these factors play a significant role in causing rework. They mentioned that the absence of proper compliance with global best practices in design auditing, such as Value Engineering, in the Nigerian Construction Industry leads to frequent changes, additions, and omissions during project execution, resulting in increased instances of rework. Furthermore,

the respondents emphasized that the lack of effective staff supervision during the project execution stage and insufficient training of personnel in the use of advanced technologies like Building Information Modeling (BIM) contribute to rework in road construction projects. They believe that inadequate supervision and the absence of training in the latest technology prevent the early detection of errors before project execution, leading to the recurring occurrence of rework.

Table 3: People Specific Rework Causes

Group C (People)

S/N	Rework Causes	Importance Index	Ranking
1	Stress (due to work overload)	55.87	4th
2	Slips	51.67	6th
3	Lack of experience and expertise	53.44	5th
4	Omission of checks	68.66	2nd
5	Wrong distribution of information	65.31	3rd
6	Misinterpretation due to lack of knowledge	71.95	1st

Moreover, the analysis identified misinterpretation due to lack of knowledge, omissions of checks, and wrong distribution of information as the top three causes in the "people-specific rework causes" category. According to the respondents, a lack of contemporary construction knowledge can lead to undesirable outcomes in construction projects. This lack of knowledge may result in design errors, improper operation of equipment, ineffective work scheduling, inefficient labor distribution, poor communication, and inadequate specifications, among other issues. Ultimately, these factors can contribute to rework or even project abandonment.

Analysis of variance (ANOVA)

Furthermore, additional analysis was conducted to determine if there were any significant differences in the opinions of the respondents based on their professional backgrounds in the Nigerian Construction Industry, namely Quantity Surveyors, Land Surveyors, Services Engineers, and Civil Engineers. Analysis of Variance (ANOVA) was employed for this purpose since it allows for the examination of significant differences among multiple variables. ANOVA helps answer the question of whether the occurrence or mean scores of different samples differ significantly from one another.

The following tables present the results of a one-way ANOVA, comparing the mean scores of responses to determine if they are significantly different from each other. The ANOVA results presented in tables (4 and 5) indicate that there is no significant difference in the opinions of the respondents, regardless of their professional affiliations. This conclusion is supported by the calculated F-ratio values of $F_{(3, 148)} = 0.985$, which are considerably lower than the critical value of 2.60. Additionally, the calculated significance values (p) exceed the 0.05 level of tolerance, with a value of 0.402. In order for a statistically significant difference to be observed, the F critical value should exceed 2.60, and the significance value (p) of the one-way ANOVA should be below the 0.05 level of tolerance.

Based on the analysis above, we can confidently generalize and draw conclusions from the responses of professionals (Quantity Surveyors, Land Surveyors, Services Engineers, and Civil

Engineers) in the Nigerian Construction Industry, as there is no significant difference in their agreement with the questions investigated in tables (1, 2, and 3).

Table 4: Descriptive statistics of Anova based on Professional Membership

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Q/Surveyors	8	4.0753	0.41552	0.06741	3.9387	4.2118	3.29	4.71
L/Surveyors	15	4.0184	0.42942	0.06966	3.8773	4.1596	3.24	4.53
S/Engineers	21	3.9271	0.46479	0.07540	3.7743	4.0799	3.00	4.63
C/Engineers	27	4.0676	0.37957	0.06157	3.9429	4.1924	3.42	4.58
Total	71	4.0221	0.42336	0.03434	3.9543	4.0900	3.00	4.71

CONCLUSION

Based on the respondents' perceptions and the analysis conducted, it can be concluded that the most severe causes of rework in road construction projects in Nigeria are pressure to finalize work, scope definition, lack of design audits, inadequate training, misinterpretation due to lack of knowledge, omissions of checks, and wrong distribution of information. These factors were ranked highest by the respondents and were attributed to factors such as extreme pressure from clients to complete projects, inadequate compliance with design auditing best practices, and insufficient contemporary construction knowledge. These findings align with the research conducted by Forcada *et al*. (2014).

Furthermore, the one-way ANOVA analysis revealed that there is no significant difference in the opinions of the respondents, including Quantity Surveyors, Land Surveyors, Services Engineers, and Civil Engineers, despite their different professional affiliations in the Nigerian Construction Industry. Therefore, we can confidently conclude and generalize the responses of all participants.

The study recommends identifying additional causes of rework from related literature to broaden the understanding of the phenomenon beyond the 23 causes espoused in this work. It also suggests expanding the research coverage to other regions of the country for comparison. Additionally, the study recommends the development of a rework warning model as an avenue for future research. These findings contribute to the existing knowledge on rework causes in road construction projects and provide insights for mitigating its occurrence in the Nigerian Construction Industry and beyond.

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