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Analysis of Cost of Rework on Time and Cost Performance of Building Construction Projects in Abuja, Nigeria

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ABSTRACT

Rework is a menace that leads to undesired and unnecessary loss of efforts, it degrades project cost and schedule performance of construction projects, both at design and construction phases. This study therefore, analyzed the impact of cost of rework on time and cost performance of building construction projects in Nigerian, using selected commercial building project within the country's capital. A pro forma was adopted for gathering data on rework cost, project cost and time of selected building projects, while structured questionnaire was used to collect information on the likely measures for reducing rework incidences from construction professionals that were involved in the delivery of the identified projects. Regression analysis, relative importance index and Kruskal-Walis test were employed for data analysis. The study revealed a significant relationship between the cost of rework and initial and final project cost of delivering commercial buildings, as an average of 3.53% impact on the initial project cost, 46.60% contribution to cost overrun, and p-value of 0.000 was observed on all assessed projects. For the project delivery time, a significant relationship between the cost of rework and initial and final project duration, as an average of 7.35% impact on the initial delivery time, extra 19 days and p-value of 0.000 was observed on all assessed projects. Team building and education, management commitment, employee involvement, were some of the best possible measures to minimized rework problems.

1. Introduction

The construction industry is the driving force behind socio-economic development of any nation; and the industry takes huge amount of money, time and energy (Saidu and Shakantu, 2016a; Meshksar, 2012). It is among the major industries that contribute to economic growth and civilization; as such its importance is approved in all communities (Meshksar, 2012). The activities of the industry improve the quality of life by providing infrastructures such as buildings, roads, hospital, schools among other facilities (Saidu and Shakantu, 2016b; Saidu and Shakantu, 2016c). In spite of the significance of the construction industry, it is always been faced with such problems as poor financial performance, high cost of project delivery, poor quality and material waste and failure to deliver value to clients on schedule (Saidu and Shakantu, 2016c; Abdul-Rahman et al., 2013).

Consequently, inefficient productivity and poor performance experienced in the construction industry has led to its wide criticisms as argued by Simpeh (2012). The cost and schedule overruns often experienced in the construction projects delivery is directly and significantly attributable to rework factors (Hwang *et al.,* 2009). Therefore, rework is one of the major factors responsible for the setback experienced in the industry as observed by (Simpeh, 2012). Love and Edwards (2004a) affirmed that rework contributes mainly to time lost and time overrun and these ultimately affect the costs, quality, resources and other project characteristics.

Rework according to Love (2002a) and Palaneeswaran (2006) is defined as the avoidable efforts expensed in re-doing activities that were incorrectly implemented at the initial time. Rework and waste have already been acknowledged as non-profitable occurrences that critically influence construction projects' productivity and performance (Josephson *et al.*, 2002; Alwi *et al.,* 2002). According to Cooper (1993), rework emerges as overtime, additional resources in the form of labour, plant, workers, and reductions in project scope and quality and schedule slippage. Love (2002a) opined that rework would naturally increase total project costs by 12.6%. Similarly, Davis *et al* (1989) reported that rework can cause additional cost to construction of up to 12.4% of the total project cost.

Mahamid (2016) analysed the cost and causes of rework in residential building projects in West Bank, Palestine. The study revealed that cost of rework in building projects ranges between 10%-15% of the original value. Oyewobi et al. (2011a) evaluated rework cost of some selected building projects in Niger state. The study focused on the relationship between rework cost and variation and time overruns of 25 selected institutional buildings projects in Niger state. The study found rework cost in different elements of the buildings studied.

Ajayi and Oyeyipo (2015) studied the effect of rework on project performance in building project in Lagos State, Nigeria.. The study revealed that a significant relationship does exist between cost of rework and original contract sum, original and final contract period, with exclusion of final contract sum. Abeku et al. (2016) carried out a study on Projects Management and the effect of Rework on Construction Works. The study found out that the combined effect of rework on the projects' time and cost were 54.70% and 28.55% respectively.

However, little has been done on rework in the geographical area of the study; and rework according to Simpeh (2012) has remained a natural problem in construction. Hence, there is the need to analyze the cost of rework on building project performance. The aim of this study is to analyze the impact of cost of rework on time and cost performance of private building construction projects of commercial nature, with a view to ascertaining the techniques for reducing rework occurrence on construction projects. The specific objectives of the study are; to determine the relationship between cost of rework and project cost (initial and final cost), to determine the relationship between cost of rework and project duration (initial and final duration), and to examine the most effective measures of minimizing rework on building projects. This study will contribute and improve understanding of construction rework. Awareness of the possible problems resulting from rework will be increased; it will also add to the body of knowledge available on rework in construction projects. The outcome of this study will have the overall effects of reducing cost and time overruns attributable to rework which will enhance project performance, and reduce or minimize possible conflicts which may arise as a result of rework.

To guide this study, the following hypothesis were made;

H_{01}- There is no significant relationship between the cost of rework and project cost

H_{02}- There is no significant relationship between the costs of reworks and project duration

2. Impact of Rework on Construction Projects

According to Palaneeswaran (2006), rework has both direct and indirect effects on the performance of construction projects. For a poorly managed projects, the overall impacts of rework may be equal to or even exceed the estimated profit margin (or mark up). Also, there are cases in which the ripple effects of rework will be carried forward on different aspects such as reputation, stress, motivation and relationships. Palaneeswaran (2006) revealed that additional time to re-do task, additional costs for re-doing work, additional materials for rework and subsequent wastage handling, and additional labour for rework and related extensions of supervising manpower; were the direct effect of the impact of rework on project management transactions. Rework can negatively affect the performance and productivity of design and construction organizations (Chan and Kumaraswamy, 1997; Love, 2002a). In addition, it is the main factor that contributes to time and cost overruns on construction projects.

Cost Overrun is a very regular incident and is associated with almost every type of projects within the construction industry (Azhar *et al.*, 2008). Cost has been seen as the major factor for measuring project success. The major factors affecting project costs are qualitative; such factors are client priority on construction time, procurement methods, contractor's planning capability and market conditions including the activity level of construction (Elchaig *et al.*, 2005). Regrettably, a lot of construction projects incur cost overruns as a result of rework. Consultants work very hard to avoid it because its resultant high effect on project cost increases (Love, 2002a). A situation in which the final cost of the project exceeds the original (initial) estimates is known as cost overrun (Avots, 1983). Cost overruns are main problems in project development; and they are regular feature in the construction industry especially for developing countries of the world (Endut, Akintoye and Kelly, 2005). Cost overruns makes projects costly for the both the contractors and clients. Odeck (2004) observed that cost overruns ranged from (59 to 183) % and are predominant on smaller projects than larger ones, especially Public Roads projects in the Norwegian construction industry. In United Kingdom construction industry, Jackson (2002) reported that almost one third of all clients experience cost overrun in their projects.

Similarly, Marosszeky (2006) found out that the mean of rework costs were 5.5% of the value of the contract; comprising 2.75% direct costs, 1.75% and 1% indirect costs for major contractors and subcontractors respectively. This study was based in New South Wales, Australia. Meshksar (2012) reported that the cost of rework is 1.30% - 3.30% of contract value, and an average of 2.095%; and rework time of 3.0%-8.0% with an average of 5.182%. Oyewobi *et al*. (2011) reported that on elemental basis, rework costs was as high as 5.29%; and that rework costs constitutes 3.47% of the entire projects studied. Oyewobi *et al*. (2011) observed a positive link between rework cost and project time overrun; indicating that increase in cost of remedying nonconforming work will give rise to increase project completion time.

Love *et al*. (1999) discovered that the cost associated with poor quality work (such as rework due to poor workmanship) were as high as 12% of the total project budgets and will require 11% of the total project schedule. Josephson and Hammarlund (1999) stated 2% - 6% of contract sum is the cost of rectifying and redoing works which do not conform to quality in the construction projects; projects such as residential, commercial and industrial building projects. In the same vein, Love and Li (2000) reported the cost of redoing and rectifying poor quality in residential building projects to be 3.15% and for industrial building projects is 2.40% of the contract sum. However, when contractors ensure effective and continuous quality improvement strategy and quality assurance systems, the cost of poor quality will be less than 1.00% of the total project cost (Love and Li, 2000). Robert (1991) reinforced this position by stating that spending extra 1.00% on prevention cost would result to 80% savings on cost of failures.

Construction project time overrun is defined as an addition of time further than the agreed contractual time at the tender stage (Endut, Akintoye and Kelly, 2005). Rework can lead to a considerable addition of a project's time and cost overrun, especially, during the construction stage. The effect of delays or time overruns for the contractor included increased costs, reduced profit margin and battered reputation (Endut *et al.*, 2005). The clients also incur some cost in the form of additional charges and professional fees and reduced incomes, which result from delayed occupancy. Most contractors believe that duration set by the client is realistic and prepare their bid accordingly; this is a factor responsible for construction delays (Ng *et al.*, 2001). Time overruns is a regular phenomenon in construction; time overruns is a common problem in most civil engineering contracts (Alkass *et al.*, 1995; Al-Khalil and Al-Ghafly, 1999). Similarly, Elinwa and Joshua (2001) reported that time overrun is a recurring decimal in the construction industry of Nigeria.

Josephson *et al* (2002) estimated that the cost of non-conformance amounted to 7.1% of total construction work hours. It is believed that the direct effects of redoing and rectifying poor quality work on project management businesses according to Palaneeswaran (2006) are; additional time for remedying failures and extension of supervision time among others. Palaneeswaran (2006) reported 277 days time overrun of a sample private building project in Hong-kong. According to Chan and Kumaraswamy (1997), completing projects within the budgeted time is an indication of an efficient construction industry; and the estimation of completion time of projects is dependent on the intuition, skill and experience of the planner/ planning engineer. Time overruns are costing Lebanon a great deal of money; therefore, there is an indisputable need to find more effective methods for overcoming rework problems (Mezher and Tawil, 1998).

3. Measure of Minimizing Rework

Wasfy (2010) suggested that many issues that should be considered in order to reduce or to minimize rework occurrences in construction projects are; design scope freezing , changes, value management, use of information technology, supervisors training, quality control plan and project inspection. One of the good techniques of reducing rework identified by Love and Edwards (2004a) is design scope freezing. Love and Edwards (2004a) maintained that design scope freezing will reduce the probability of rework occurrences. The difference between the contractual requirements contained in the original contract between the parties and the additional requirements during the actual construction of the project is known as change (Oracle White Paper, 2009). Changes could be classified as directed (owner originated) or constructive (contractors-oriented) changes. These changes whether initiated by either the owner/contractor may cause rework; thus minimizing changes means reducing occurrence of rework. Peter et al. (2010) emphasised the role of skilled work force, good communication, employee involvement and management commitment in improving quality and curtailing waste and rework in construction. It is obvious that the participation of subcontractors at both the planning and construction stage will lead to increased effective communication between subcontractors and their main contractors. This will translate to effective and proper coordination of site activities, which will eventually reduce the incidence of rework (Simpeh, 2012).

The management commitment is one of the most essential factors to implementing quality Management in construction industry; and this factor is considered the most influential according to (Al-Tayeb, 2008). Simpeh (2012) observed that team building, involvement of subcontractor/suppliers during design , design for construction were the most effective design management strategy for reducing rework incidence on construction projects. Furthermore, to reduce rework, Simpeh (2012) found out that the most effective site management strategies for reducing rework are involvement of subcontractors during construction, and quality control.

4. Methodology

The study covers the analysis of cost of rework on construction project performance with emphasis on time and cost performance of some selected private building projects executed between years 2005-2015 in Abuja, Nigeria. The private building projects considered in the study area include shopping complexes and malls of commercial nature completed within the period under study by reputable contractors and consultants. Such projects are funded by serious minded investors, individuals or organisations/companies who are profit driven. The period of 10 years (2005-2015) was chosen to have more projects and data to investigate. Abuja was selected for this study because it is the administrative headquarters of Nigeria and the ease of access to project archives of the selected companies. Also, being one of the metropolitan cities in Nigeria with the high population of contracting and consulting firms and professionals within the built environment. Shopping malls/complexes are seen scattered all over the city and its suburbs, and buying and selling has remained in spite of economic conditions and recession in the country.

A total number of 61 commercial building identified to have experienced rework during their execution were selected for the study after contacts with the participants were established. These project formed the population of the study, together with the participants involved in the delivery of these construction projects. However, in the course of gathering data, access was allowed to only 31 of them. The 31 projects formed the basis of the study, as they were found adequate for the needed information were available. This number is enough for generalization about the whole population to be made. A pro forma was used to collected the data on project cost and project time and rework cost for the projects. These data were extracted by the researchers from the Bill of quantities, valuations and final counts, claims sheet, and variation accounts. Structured questionnaire was administered randomly to 365 participants, who were associated with these building projects. These participants covers professionals who worked with the clients, the contractors, the consultants and sub-contractors; in ensuring that the projects are delivered. 188 of the questionnaires were retrieved out of the 365 distributed, representing 51.5% response rate, and was deemed fit for the analysis.

The questionnaire used was designed in two sections using information derived from related literatures reviewed. Section A covered the demographic information of the target respondents. Information gathered from section A served as a quality check and verification of the data from the other part of the questionnaire. Section B covered the views of the project participants on the possible measures for reducing rework in construction, which will in turn minimize or eliminate cost and time overruns of private building projects. 25 possible measures were selected from the review of related literatures, and respondents were requested to rate these measures base on the level of efficacy in reducing rework when implemented on construction projects using a 5-point Likert scale, where 1 = very Ineffective, 2 = Ineffective, 3 = Average, 4 = Effective, 5 = very Effective

The appropriateness and suitability of the research instrument to meet the study objectives was carried out through a pilot survey as suggested by Fellows and Liu (2008). Fifteen of the draft questionnaire were randomly distributed to the selected experts, and the final draft was adjusted based on their feedback. Furthermore, the reliability and internal consistency of the questionnaire was carried out using Cronbach's alpha test. This method measured the reliability of each of the field of the questionnaire and the mean of the entire fields of the same questionnaire. The acceptable value range of Cronbach alpha is between 0 and +1, and as the value tends toward 1, the higher degree of internal consistency. The Cronbach alpha value for the measured variables is 0.911, thereby implying that the questionnaire is credible and have high degree of reliability. According to Moser and Kalton (1999), a research instrument is more perfect as the value of the Cronbach alpha tends towards 1.0.

Frequencies, percentages, relative importance index (RII) were used to analyse the collected data from the questionnaire; and Kruskal-Walis test performed to determine the relationship in the view of the respondents regarding the variables. Furthermore, the project cost, project time and rework cost data collected were analysed using regression analysis. The regression analysis was used in determining the relationships between the cost of rework and project time, and project cost. Regression analysis was employed to determine the relationship between the dependent variables (project time and cost) and independent variables (Cost of rework),

5. Results and Discussion

5.1 General Information of the Respondents

The analysis of the respondent's characteristic shows that in the organisational type of respondents; 51.60% of them work with contractors, 20.74% and 25.0% work in the consultants and clients organisation respectively, and 2.66% in consulting/contracting firms. For years of experience worked in the construction industry; 48.40% of them had 1-10 years, 39.89% had 11-20 years, 9.04% and 2.66% of them had 21-30years and 31.40years respectively, while non had 41years and above. Most of the participants holds Bachelor of Science/Bachelor of Technology degree (46.28%), this is followed by those with Higher National Diploma (29.79%) and Master of Science/Master of Technology degree (21.81%), and lastly PhD holders (2.13%). This imply that the respondents are experienced and academically qualified to give reliable information in such construction base study. In addition, according to the respondents, 74.5% always keep records of rework incidences, 23.94% keeps record sometimes, and only 1.56% of them had never kept rework of rework incidences. The respondents are of the opinion that the activities of contractors contribute 37.77% to rework, followed by the consultants (31.38%) and then the client/owner/customer (18.09%).

The analysis also revealed that, 32.45% of the respondents are Quantity surveyors and are registered members of the Nigerian Institute of Quantity Surveyors (NIQS). Engineers (Civil and Services) (27.13%) and Architects (23.40%) and are members of the Nigerian Society of Engineers (NSE) and Nigerian Institute of Architects (NIA) respectively. 17.02% of them are Builders registered with the Nigerian Institute of Building (NIOB). The high proportion of quantity surveyors implies that they are involved in cost-associated matters such as rework in the construction industry; and evidence of professional memberships shows that they are professionally qualified to give an expert opinion on the subject of this study.

5.2 Relationship between Cost of Rework and Project Cost

To determine the relation between cost of rework and cost of project, a regression analysis was undertaken and the result is shown on Table 1. The analysis revealed that there is a relationship between the cost of rework (independent variable) and the Projects costs (dependent variables) for the 31 selected building projects studied. In all, it was discovered that there exists a very strong, positive and significant relationship between the variables (that is, between cost of rework and initial project cost, final project cost).

The analysis between the cost of rework and initial project cost shows that the coefficient of determination (R^2) observed has a very high value of 73.8% implying that 73.8% changes in the value of project cost is due to the cost of rework while the remaining 26.2% was due to other factors not considered by this study. The positive correlation observed implies that increase in the value of the independent variable is accompanied by a corresponding increase in the value of the dependent variable and vice-versa. The $F_{calculated}$ value of 81.606 observed was greater than the $F_{tabulated}$ value of 4.18 and the P-value of 0.000 observed was less than 0.05. Based on these, the null hypothesis which states that there is no significant relationship between the cost of rework and

Table 1: *Simple Linear Relationships Analysis for Cost of Rework and Project Cost*

Variables	Dependent Variables							
	Initial cost of projects				Final Contract Sum			
	B	SE B	β	Sig.	B	SE B	β	Sig.
Constant	1.03E+09	2.77E+08		0.001	1.09E+09	2.91E+08		0.001
Cost of Rework	17.656	1.954	0.859	0.000	19.155	2.053	0.866	0.000
R		0.859				0.866		
R^2		0.738				0.750		
Adjusted R^2		0.729				0.742		
F_{cal}		81.606				87.068		
F_{tab}		4.18				4.18		

project cost was not accepted.

The analysis between cost of rework and final project cost revealed that the coefficient of determination (R^2) observed has a very high value of 75.0% implying that 75.0% changes in the value of project cost is due to the cost of rework while the remaining 25.0% was due to other factors not considered by this study. The positive correlation observed implies that increase in the value of the independent variable is accompanied by a corresponding increase in the value of the dependent variable and vice-versa. Meaning that any further rework incidence can increase what the value of the final contract sum will be, even after it has been projected at some point during the construction. Since te $F_{calculated}$ value of 87.068 observed was greater than the $F_{tabulated}$ value of 4.18 and the P-value of 0.000 observed was less than 0.05, the null hypothesis was not accepted.

5.3 Relationship between Cost of Rework and Project Delivery Time

Similarly, a regression analysis also undertaken to ascertain the relationship between cost of rework and project time, and the result is shown on Table 2. The analysis revealed that there is a relationship between the cost of rework (independent variable) and the Projects duration (dependent variables) for the 31 selected building projects studied. It was discovered that there exists a strong, positive and significant relationship between the variables (that is, between cost of rework and initial project duration and final project duration).

The analysis between the cost of rework and the initial project duration showed that the coefficient of determination (R^2) observed has a very high value of 54.9% implying that 54.9% changes in the value of project duration is due to the cost of rework while the remaining 45.10% was due to other factors not considered by this study. The positive correlation observed implies that

Table 2: *Simple Linear Relationships Analysis for Cost of Rework and Project Duration*

Variables	Dependent Variables							
	Initial Project Duration				Final project duration			
	B	SE B	β	Sig.	B	SE B	β	Sig.
Constant	432.649	25.46		0.000	457.699	26.954		0.000
Cost of Rework	1.07E-06	0.0000	0.741	0.000	1.22E-06	0.0000	0.765	0.000
R		0.741				0.765		
R^2		0.549				0.585		
Adjusted R^2		0.534				0.571		
F_{cal}		35.349				40.934		
F_{tab}		4.18				4.18		

increase in the value of the independent variable is accompanied by a corresponding increase in the value of the dependent variable and vice-versa. The $F_{calculated}$ value of 35.349 observed was greater than the $F_{tabulated}$ value of 4.18 and the P-value of 0.000 observed was less than 0.05. Based on these, the null hypothesis which states that there is no significant relationship between the costs of reworks and project duration was rejected.

In the same vein, the analysis between cost of rework and final project duration revealed that the coefficient of determination (R^2) observed has a very high value of 58.5% implying that 58.5% changes in the value of project duration is due to the cost of rework while the remaining 41.50% was due to other factors not considered by this study. The positive correlation observed implies that increase in the value of the independent variable is accompanied by a corresponding increase in the value of the dependent variable and vice-versa. The $F_{calculated}$ value of 40.934 observed was greater than the $F_{tabulated}$ value of 4.18 and the P-value of 0.000 observed was less than 0.05, based on these, the null hypothesis was rejected.

The analysis of the data collected from a total of 31 selected public building projects revealed that, in all there exists a very strong, positive and significant relationship between the variables (cost of rework, project cost and project duration) tested. This Imply that an increase in the cost of rework can cause additional cost to the project which could require extra time. This finding is consistent with the following previous studies on rework; Oke and Ugoje (2013) who reported that there is a significant relationship between rework cost and initial cost, final cost, cost overrun, initial time, final time and time overrun. Oyewobi *et al*. (2011a) reported a positive link between rework cost and project time overrun at 5% level of significant; there was a positive correlation between rework and initial cost, cost overrun and time overrun of the projects studied at 1% level of significant. This therefore indicates that increase in cost of remedying nonconforming work will give rise to increase project completion time. Ajayi and Oyeyipo (2015) reported that there is significant relationship between the cost of rework and initial contract sum, initial and final contract period; but not with the of final contract sum.

A further analysis the data revealed that rework represent 3.53% and 3.28% of the initial and final project cost respectively and constituted 46.6% of the cost overruns experienced in the 31 selected projects. Similarly, time overrun due to rework represent 7.35% and 6.85% of the initial and final project duration respectively, with these, rework lead to an average of 19 extra days to the durations of the projects studied. This finding corroborates previous studies on rework (Chan and Kumaraswamy, 1997; Love, 2002a; Love and Edwards, 2004a; Hwang *et al*., 2009). These studies agreed that rework is the main cause of (and significant contributor to) cost and time overrun. It is also consistent with Burati *et al*., (1992), Wasfy (2010), Love and Edwards (2004a) who posited that rework adversely affect construction project performance in form of cost overruns, time overruns, schedule slippage, quality degradation, dissatisfaction, additional labour and plant, reduced project scope, conflict and professional relations.

Previous studies with higher rework cost value; Love (2002a) reported that rework would naturally increase total project costs by 12.6%. Davis *et al*. (1989) reported that rework can cause additional cost to construction of up to 12.4% of the total project cost. Gunawardena *et al*. (2004) revealed that the cost of rectifying non-conformance (rework) is on the average of 10% of total contract sum. Burati *et al*. (1992) discovered that deviation in project quality accounted for 12.4% of the total project cost of engineering projects. Egan (1998) reported high rework cost in building projects of 30%. Love *et al*. (1999) discovered that the cost associated with poor quality work (such as rework due to poor workmanship) were as high as 12% of the total project budgets and will require 11% of the total project schedule. Abeku *et al*. (2016) reported a combined effect of rework on the projects' time and cost of 54.75 and 28.20% respectively.

Previous studies with same or slightly higher rework cost value; Marosszeky (2006) reported that the mean of rework costs were 5.5% of the value of the contract; comprising 2.75% direct costs, 1.75% and 1% indirect costs for main contractors and subcontractors respectively. Low and Yeo (1998) posited that a typical contractor in the construction industry spends an average of 5 -10% of the total project budget in producing poor quality works and remedying them later. Josephson and Hammarlund (1999) stated 2% - 6% of contract sum is the cost of rectifying and redoing works which do not conform to quality in the construction projects. Love and Li (2000) reported the cost of redoing and rectifying poor quality in residential building projects to be 3.15% and for industrial building projects is 2.40% of the contract sum. Meshksar (2012) reported that the cost of rework is 1.30% - 3.30% of contract value, and an average of 2.095%; and rework time of 3.0%-8.0% with an average of 5.182%. Oyewobi *et al*. (2011a) reported that on elemental basis, rework costs was as high as 5.29%;

and that rework costs constitutes 3.47% of the entire projects studied. Abdul-Rahman (1995) reported a lower cost of non-conformance of 5% of contract sum for a highway project. Josephson *et al* (2002) estimated that the cost of non-conformance amounted to 4.4% of the construction values, and 7.1% of total construction work hours.

Having reported that rework cost can naturally be up to 12.6% of project cost, Loves (2002a) argued that some construction projects are capable of showing high cost of rework costs. Implying that rework incidences and their associated costs can be lower or higher in the construction industry.

5.4 Rework Minimisation Measures

In order to establish the best possible measures of minimising rework incidences in private developments, the respondents were asked to rank the measures identified from literature based on their level of effectiveness in reducing/avoiding their occurrences when implemented. Table 3 shows the ranking of these measures. Kruskal-Walis test was conducted to determine the consistency in the perception of the four sets of professionals. This test is suitable for use were the there is need to establish if a significant difference exist or not in the views of three or more groups of respondents.

It can be seen that the top five most effective measures of minimizing rework as suggested by the Under the Builders are; Team building and education, Communication between managers and employees, Design for construction (i.e. standardized components), Value management, and Management commitment. Whilst, the Quantity Surveyors are of the oipinion that Team building and education, Management commitment, subcontractor/suppliers during design, Employee involvement, and Involvement of subcontractors during construction, are most effective measures for reducing rework.

In the opinion of the Architect, Design for construction (i.e. standardized components), Team building and education, Communication between managers and employees, Management commitment, and subcontractor/ suppliers during design and Employee involvement with tied RII of 0.850; are the most effective for reducing rework on construction projects. For the Engineers; Team building and education, Involvement of subcontractor/ suppliers during design, Management commitment, Employee involvement, and Communication between managers and employees; are most suitable measures of reducing construction rework.

On the overall, the most effective means of reducing construction rework are Team building and education, Management commitment, Employee involvement, Communication between managers and employees, and Involvement of subcontractor/suppliers during design.

Kruskal-Walis test carried out at 95% confidence level,shows that there is a significant difference in the ranking of two of the measures for reducing the rework incidences in private buildings as indicated by the four categories of respondents. These measures recorded a p-vale of less than 0.05, and they are Design for construction (i.e standardised components), and Organisational culture. The difference is can be attributed to the ways the 4 categories of respondents view these measures. However, the test also shows that there is no significant difference in the ranking of 23 of the measures for reducing the rework incidences in private buildings projects as perceived by the respondents. These measures recorded a significant p-value of above 0.05.

The study revealed that the top most effective means of reducing construction rework are Team building and education, Management commitment, Employee involvement, Communication between managers and employees, and Involvement of subcontractor/suppliers during design. This finding corroborates with the report of Simpeh (2012), who reported that team building, involvement of subcontractor/suppliers during design , design for construction were the most effective design management strategy for reducing rework incidence on construction projects. Simpeh (2010) observed that the involvement of subcontractors during construction, quality control are the most effective site management strategies for reducing rework. Peter et al. (2010) emphasis the role of skilled work force, good communication, employee involvement and management commitment in improving quality and curtailing waste and rework in construction. It is obvious that the participation of subcontractors at both the planning and construction stage will lead to increased effective communication between subcontractors and their main contractors. This will translate to effective and proper coordination of site activities, which will eventually reduce the incidence of rework (Simpeh, 2012).

The management commitment is one of the most essential factors to implementing quality Management in construction industry; and this factor is considered the most

***Table 3**: Rework Minimization Measures*

S/ No	Measures	Bldr.		Q. S		Arch.		Engr.		Overall		Kruskal-Walis	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank	Chi Sq	P-value
1	Team building and education	0.91	1	0.92	1	0.88	2	0.93	1	0.91	1	2.722	0.436
2	Communication between managers and employees	0.86	2	0.82	6	0.86	3	0.84	5	0.84	4	1.700	0.637
3	Design for construction (i.e. standardized components)	0.86	3	0.80	15	0.89	1	0.77	15	0.83	6	8.178	0.042*
4	Involvement of subcontrac-tor/suppliers during design	0.74	17	0.88	3	0.85	5	0.85	2	0.83	5	3.785	0.286
5	Organizational culture	0.70	23	0.78	18	0.67	24	0.67	23	0.71	23	8.223	0.042*
6	Value management	0.84	4	0.72	22	0.77	15	0.76	17	0.77	16	4.140	0.247
7	Constructability analysis	0.76	13	0.68	25	0.78	13	0.76	18	0.74	20	3.628	0.304
8	Review/analysis used to improve performance	0.81	7	0.79	17	0.83	7	0.83	6	0.81	8	0.658	0.883
9	Computer visualization techniques	0.75	15	0.80	11	0.77	15	0.78	13	0.77	14	0.974	0.807
10	Employee involvement	0.83	6	0.87	4	0.85	5	0.84	4	0.84	3	1.363	0.714
11	Involvement of subcontrac-tors during construction	0.81	7	0.86	5	0.81	9	0.78	11	0.82	7	1.768	0.622
12	Clearly defined goals and objectives	0.67	25	0.77	20	0.66	25	0.66	24	0.69	25	6.234	0.101
13	Design scope freezing	0.76	13	0.80	11	0.80	12	0.80	9	0.79	13	0.779	0.854
14	Quality control plan	0.79	9	0.80	13	0.78	14	0.78	11	0.79	12	0.083	0.994
15	Site quality management system	0.79	9	0.76	21	0.82	8	0.82	7	0.80	11	1.789	0.617
16	Regular inspections and audits	0.71	20	0.78	19	0.71	23	0.71	22	0.73	22	2.685	0.443
17	Value engineering	0.74	18	0.81	7	0.75	19	0.76	18	0.76	17	0.774	0.856
18	Management commitment	0.84	4	0.89	2	0.85	4	0.85	3	0.86	2	3.719	0.294
19	Well-defined roles and responsibilities	0.78	11	0.81	7	0.81	9	0.82	8	0.81	9	0.382	0.944
20	Written quality program or policy	0.75	15	0.79	16	0.77	15	0.78	13	0.77	15	1.188	0.756
21	use of information technolo-gy	0.70	23	0.70	24	0.73	22	0.65	25	0.69	24	2.146	0.543
22	Supervisors training	0.71	21	0.80	13	0.76	18	0.77	16	0.76	18	2.192	0.533
23	Reduction of client/ contractor oriented changes	0.71	21	0.81	9	0.74	21	0.75	20	0.75	19	4.376	0.224
24	Skilled workforce	0.78	11	0.81	9	0.81	9	0.80	9	0.80	10	0.268	0.966
25	Regular meetings	0.74	18	0.70	23	0.74	20	0.75	20	0.73	21	1.006	0.800

N = 32 for Building, N = 61 for Quantity Surveyor, N = 44 for Architect, N = 51 for Engineering, df = 3

influential according to (Al-Tayeb, 2008). Management support and commitment is therefore, critical if rework is to be reduced to a minimum. Love and Edwards (2004a) posited that constructability and value management (VM) programmes are key activities to be undertaken after the creation of baseline scopes. Furthermore, for design-related rework to be reduces, the key strategies include constructability analysis, team building, value management and scope freezing (Love, 2001). Therefore, if management seek to reduce investment in wasteful activities, value management should be performed at the early stages of project development; and should involve project team, contractors and subcontractors (Love and Edwards, 2004a).

6. Conclusion and Recommendations

The study covers the analysis of cost of rework on construction project performance with emphasis on time and cost performance of some selected private building projects of commercial nature, with a view to determining the most effective measures of reducing rework occurrence on construction projects. The study revealed that there is a very strong, positive and significant relationship between the cost of rework and project cost; and strong, positive and significant relationships between the costs of rework and project duration. This showed that rework is a major cause of cost and time overrun experienced in construction projects. Furthermore, it was concluded that Team building and education, Management commitment, Employee involvement, effective communication between managers and employees, and Involvement of subcontractor/suppliers during design, are the most effective measures of minimizing rework.

Based on these conclusion, it is recommended that Project participants should be alert and have good foresight for rework risk triggers and eliminate them prior to commencement of work on site to avoid rework emergence at construction. This will greatly check their occurrence and the cost and time performance of construction projects are improved. There should be efficient and effective communication among the design consultants, engagement of adequately skilled professionals to complete contract documents prior to awards, ensures involvement of entire project team and the contractor and subcontractors should not be excluded in finding lasting solution to reducing rework incidences. Also encouraged is the development of teambuilding and relationship models that will stimulate inter-organizational relations and promote good team spirit at the inception stages of a project, which is will have impact on reducing design-induced rework. A similar study should be carried out on private residential estate projects within Abuja. This has become necessary due to the proliferation of housing estates within the city to meet housing demand.

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