Environmental Technology & Science Journal
Vol. 9 No. 2 December 2018

Implication of Rework on Selected Residential Building Projects in Lagos, Nigeria

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The average cost of acquiring residential buildings in Lagos is high. The reason for this has been traced to many factors among which rework appears to be at the top. The aim of this study was to investigate the implication of rework on selected residential building projects in Lagos, Nigeria. The quantitative research method was adopted for the study. The convenience sampling technique was used to collect data from selected building projects consisting of (41) residential building projects (31 private and 10 public) in Lagos metropolis. The study employed the quantitative (questionnaire) research technique. The information of the buildings was supplied by contractors or consultants of the projects investigated, depending on the person available. The data collected were analysed using descriptive (frequency, percentage, mean score) and inferential (t-test) statistics. Results indicate that rework contributed about 10.28% to the cost of residential building projects. Substructure, Mechanical and Electrical installations, frames and upper floors, and finishing were the elements that contributed the most to the cost of rework in building projects. Also, there is no significant difference in the causes of rework for both public and private resident projects. The suggested methods of reducing rework are good supervision, coordination, standardization, effective quality control plan, and effective design management. The study concluded that the causes of rework are mostly design-related and they are different for government-owned and private residential buildings. Hence, it was recommended that designers/consultants should visit construction sites before recommending any type of substructure, and projects should be supervised and coordinated by experienced personnel.

Keywords: Building elements, cost overrun, project cost, residential building, rework

Introduction

The construction industry occupies a focal position in the economy of any nation (Oyewobi & Ogunsemi, 2010) because it contributes to the process of national development by way of employment and economic growth (Oyewobi, Ibironke, Ganiyu & Ola- Awo, 2011). However, it is a perennial problem that construction projects overrun their budgeted cost. Oyewobi and Ogunsemi (2010) substantiated that the problem of cost overrun may not yet be over, as it characterizes construction projects in most parts of the world especially in developing countries like Nigeria.

Some of the reasons adduced to cost overrun are design errors (Dosumu & Iyagba, 2013; Dosumu, 2018), quality deviations, design changes and rework (Josephson & Hammarlund, 1999; Love, Irani & Edwards, 2004). However, Love, Edwards, Smith and Walker (2009) labelled rework as a major cause of cost overrun in the construction industry. Therefore, studies towards the minimization of rework are required to ameliorate the continual problem of cost overrun. Love (2002) noted that rework adds about 2.5-15% to the initial contract sum.

Rework usually occurs at the construction stages of projects and it may be in the form of variation, design error and/or omission. Rework also occurs at the design-construction interface when design drawings are generally incomplete, not explicit and an important proportion of the problems detected during construction are due to lack of constructability of the designs (Love, 2002 & Oyewobi *et al*, 2011). Governments (state and federal), corporate organizations and construction investors usually develop residential buildings for citizens and employees in order to alleviate their accommodation problems and increase proximity to their workplaces. However, these buildings are usually sold at high prices with claims that construction costs are high and exceed budget (Ogunsemi & Jagboro, 2006). Rework contributes significantly to construction cost overrun and it directly leads to clients' dissatisfaction, reduction of profitability and in extreme conditions, leads to an acrimonious relationship among participants (Love, 2002).

In this study, residential building projects in Lagos metropolis were the subject of investigation because of the high volume of construction activities by private and public institutions in the state. These houses tend not to solve the problem of accommodation in the state because they are usually sold at unaffordable prices with claims that the cost of completing the buildings are high. Many construction employees currently live in slums, Lagos state suburbs and travel huge distances to get to their workplaces because they could not afford the houses in the heart of the state. This has not only reduced the productivity of construction workers, it has also led to ill-health and in some cases, death. In view of this, the study evaluates the causes of rework, the cost implication of rework on residential buildings, building elements that contribute the most to rework cost, and the methods of minimizing rework on building projects. The study also tests two hypotheses:

$H_{1\ null}$: There is no significant difference in the causes of rework between public and private residential buildings

$H_{1\ alternative}$: There is significant difference in the causes of rework between public and private residential buildings

$H_{2\ null}$: There is no significant difference in the methods of reducing rework between public and private residential buildings

$H_{2\ alternative}$: There is significant difference in the methods of reducing rework between public and private residential buildings

Literature Review

Rework was explained by Love, Mandal, Smith and Geogiou (2006) as the unnecessary efforts of redoing a process or an activity that was incorrectly implemented at the first time. It is also the non-required effort of re-doing a process or activity that was wrongly executed at the first time (Love & Edwards, 2004). Oyewobi *et al* (2011) sees rework as a waste that involves doing certain task more than once.

Love and Edwards (2004), Hwang *et al.* (2009) and Burati *et al.* (1992) identified the root causes of rework as errors, omissions, failures, damage, poor leadership, poor communication and ineffective decision making. Studies by Love, Mandal and Smith (2000) emphasized the fact that rework originates more from the design stage than the construction stage. It was also found that 50% of the origin of errors which leads to rework in buildings occur in the design stage and 40% occur during the construction stage. Love *et al.* (2000) stated that lack of communications between clients and design consultants is a big contributor to rework.

It was noted by Love *et al.* (2000) and Dosumu *et al.* (2017) that insufficiently advanced design may cause rework. Josephson and Hammarlund (1999) suggested that the causes of rework are incomplete designs, change in the method of construction and omission made during design. Love *et al.* (2004) suggested that time boxing (limited duration) of design tasks could result to insufficiently advanced contract documents which could lead to rework. Love *et al.* (1999) argue that rework occurs as a result of uncertainty, poor leadership, poor communications, ineffective decision-making and poor project management practices. Love *et al.* (2004) suggested that poor technical knowledge and lack of experience can result in errors and omissions in contract drawings which may lead to rework. Josephson *et al.* (2002) declared that faulty manufacturing of material is a main contributor to rework. Apart from these direct causes of rework, Love *et al.* (2000) noted that stress, fatigue, absenteeism, de-motivation, and poor morale are indirect causes of rework at the individual level.

Oyewobi and Ogunsemi (2010) affirmed that rework has negative impact on the cost performance of construction projects. It was reported that the actual cost of rework for a contractor may be less than one percent of contract value (Love *et al.*, 1999) and that a contractor will invariably always try to offload any additional costs to his client and subcontractors. Contractor's estimates/tender figures may also allow for some degree of rework (in the form of contingency) based on their knowledge and experience from previous and similar projects undertaken. Thus, the actual cost of rework to a contractor may even be negligible while the client bears all the brunt (Love *et al.*, 1999).

Josephson and Hammarlund (1999) reported that the rework costs of residential, industrial, and commercial building projects range from 2 to 6% of their contract values in Sweden. Similarly, Love and Li (2000) claimed that rework costs for residential and industrial buildings are 3.15 and 2.40% of contract values respectively in Australia. Barber *et al* (2000) reported rework costs to be 6% of project cost in United Kingdom. Love *et al* (2000) reported 12.4% as rework cost of construction projects in United States of America. Burati *et al.* (1992) studied nine major engineering projects and found that for all nine projects, rework accounted for an average of 12.4% of the contract value. A significantly lower figure was reported by Abdul-Rahman (1995) who found rework costs excluding material wastage and head office overheads in a highway project to be 5% of the contract value. The implication of rework on residential building projects have been scantily investigated (when compared with engineering projects) despite their (residential building projects) importance to the health, comfort and productivity of the people. hence the need for this study.

Love and Li (2000) noted that when a contractor implements quality assurance system in conjunction with an effective continuous improvement strategy, rework costs were less than 1% of the contract value. Another method of reducing rework is by adoption of information technology (Rivard, 2000). Since many causes of rework originate during the design phase, effective design management has been reported as a key factor to reducing rework (Love *et al.*, 2000). If rework is to be reduced or avoided there is need for clients to initiate construction activities that can reduce changes or alteration to design after commencement of work (Palaneeswaran, Kumaraswamy, Ng, and Love, 2006).

Design scope freezing was identified by Love and Edwards (2004) as a good technique to reduce changes which consequently will reduce the probability of rework occurrences. Alarcon and Mardones (1998) noted that rework can be reduced with the supervision of design process, coordination of different specialties, standardization of design information and control of flow of information. Also, if rework in construction is to be reduced or eliminated there is need for consensus on a workable mechanism to bring together the client, consultant, and contractor to minimize change orders and introduction of additional works during construction phase (Oyewobi *et al.*, 2011).

Research Methodology

This study was conducted in Lagos metropolis because, Lagos is the economic and commercial hub of Nigeria. Lagos also has a high volume of construction activities as well as concentration of building contractors, clients' organisations and consultancy firms. Most of the major building contractors in Nigeria have their head offices or at least a branch/operation office in Lagos which also houses a rich collection of construction industry practitioners and experts. The high demand for residential buildings among others in Lagos also necessitates its consideration for this study.

Hence, the sample frame of this study is the private and public residential building projects that were completed in Lagos between 2012 and 2016. The choice of 2012 to 2016 was to ensure that, projects used for the study are not only recent, but the variations in their unit cost are within close inflation rate.

The information about each project was collected from contractors, consultants or clients. The quantitative research method was used for the study. The convenience sampling technique was used to select 61 residential projects out of which 41 (31 private and 10 public) of them were returned for data analysis. Hence, 41 residential projects were used for the analysis of this study. Since it was difficult to compile a unified list of residential building projects that were completed between 2012 and 2016, the study employed the convenience sampling technique. The study assumed normal distribution of the variables of the study, hence, the data were analysed with descriptive (frequencies, percentages, mean item score) and inferential (t-test) statistics. The frequencies and percentages were used to describe the profile of respondents and their organizations. The mean score was used to rank the respondents' opinion on the objectives of the study, and the t-test was used to test the hypotheses of the study.

Results and Discussion of Findings

Out of the 41 residential buildings that were investigated, 31 (76%) were for private residential buildings and 10 (24%) were for public residential buildings. Table 1 shows the general information of the respondents and selected residential buildings used for the study.

Table 1: General information of respondents and residential buildings

	PUBLIC		PRIVATE		BOTH	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Background of respondents						
Quantity surveying	10	24.4	23	56.1	33	80.5
Building	0	0	5	12.2	5	12.2
Architecture	0	0	2	4.9	2	4.9
Engineering	0	0	1	2.4	1	2.4
Total	10	24.4	31	75.6	41	100
Work experience						
1-5 years	2	4.9	19	46.3	21	51.2
6- 10 years	3	7.3	9	22	12	29.3
11-1 5 years	2	4.9	2	4.9	4	9.8
16-20 years	0	0	1	2.4	1	2.4
Above 20 years	3	7.3	0	0	0	7.3
Total	10	24.4	31	75.6	41	100
Academic qualifications						
OND	0	0	2	4.9	2	4.9
HND	2	4.9	8	19.5	10	24.4
BSC	5	12.2	17	41.5	22	53.7
MSC	3	7.3	4	9.8	7	17.1
Total	10	24.4	31	75.6	41	100
Professional qualification						
NIQS	10	24.4	23	56.1	33	80.5
NIOB	0	0	6	14.6	6	14.6

NSE	0	0	2	4.9	2	4.9
Total	10	24.4	31	75.6	41	100
Type of accommodation						
2-bedroom	4	9.8	17	41.5	21	51.2
3 –bedroom	1	2.4	9	22	10	29.4
Mixed apartment	5	12.2	3	7.3	8	19.5
Duplex	0	0	2	4.9	3	4.9
Total	10	24.4	31	75.6	41	100
Year of commencement						
2009	-	-	4	9.8	4	10.0
2010	-	-	2	4.9	2	5.0
2011	2	4.9	6	14.6	8	20.0
2012	4	9.8	8	19.5	12	30.0
2013	3	7.3	7	17.0	10	25.0
2014	1	2.4	4	9.8	5	13.0
Total	10	24.4	31	75.6	41	100.0
Year of completion						
2013	1	2.4	5	12.2	6	15.0
2014	1	2.4	4	9.8	5	12.0
2015	3	7.3	11	29.2	14	35.0
2016	5	12.2	10	24.4	15	38.0
Total	10	24.4	31	75.6	41	100.0

The background of the respondents indicates that, 80.5% studied quantity surveying, 12.2% studied building, 4.9% studied architecture and 2.4% studied engineering. This indicates that majority of the respondents were quantity surveyors. This may be because, the kind of information required for the study could easily be provided by quantity surveyors among other professionals in the built environment. The work experiences of the respondents were 51.2% for 1-5 years, 29.3% for 6-10 years, 9.8% for 11-15 years, 2.4% for 16-20 years and 7.3% for "above 20 years". This indicates that majority of the respondents have between 1 and 10 years of work experience, which is enough for the professionals to supply useful information for the study. The academic qualifications of the respondents indicate that 4.9% had OND, 24.4% had HND, 53.7% had BSc and 17.1% had M.Sc. This shows that majority of the respondents had sufficient education to respond to the queries of the study. On professional qualifications, 80.5% of the respondents had NIQS, 14.6% had NIOB and 4.9% had NSE and this denotes that, the respondents are qualified (professionals) to give useful information for the study. The types of accommodation in the residential buildings investigated indicated that 51.2% were 2-bedroom apartments, 29.4% were 3-bedroom apartments, 19.5% were mixed apartments, and 4.9% were duplexes. For private residential buildings, 2-bedroom apartments (41.5%) and 3-bedroom (22%) apartments were prevalent. Analysis of the commencement dates of the buildings indicated that, 10% of them were commenced in 2009, 5% were commenced in 2010, 20% were commenced in 2011, 30% were commenced in 2012, 25% were commenced in 2013 and 13% were commenced in 2014. However, 15% of the buildings were completed in 2013, 12% were completed in 2014, 35% were completed in 2015 and 38% were completed in 2016 respectively.

Tables 2 shows the significant causes of rework in the residential buildings investigated in this study. Design /construction changes (3.61), defects in buildings (3.22), design error (3.20), quality failure (3.15), incompetent supervisor (3.15), poor workmanship (3.10), wrong/defective materials (3.10), incomplete designs (3.08), quality derivations (3.05), damage (3.05), non-conformance (3.05), and complicated construction programmes (3.05) were ranked highest by the respondents.

Table 2: Respondents' perception on causes of rework in public and private residential buildings

Causes of rework	Public Mean	Rank	Private Mean	Rank	Total Mean	Rank
Design/construction changes	3.40	1	3.68	1	3.61	**1**
Defects in buildings	3.30	2	3.19	2	3.22	**2**
Design errors	3.30	2	3.16	5	3.20	**3**
Quality failure	3.00	9	3.19	2	3.15	**4**
Incompetent supervisors	3.20	5	3.13	6	3.15	**5**
Poor workmanship	3.00	9	3.13	6	3.10	**6**
Wrong materials/defective materials	2.90	15	3.17	4	3.10	**7**
Incomplete designs	3.20	5	3.03	11	3.08	**8**
Quality deviations	2.90	15	3.10	8	3.05	**9**
Damage	3.20	5	3.00	12	3.05	**10**
Non-conformance	2.90	15	3.10	8	3.05	**11**
Complicated construction program	3.30	2	2.97	13	3.05	**12**
Inadequate supervisory/managerial skills	2.70	19	3.06	10	2.98	**13**
Change in the method of construction	3.00	9	2.97	13	2.98	**14**
Lack of coordination and planning	3.10	8	2.90	15	2.95	**15**
Omission	3.00	9	2.84	16	2.88	**16**
Poor construction management policies	3.00	9	2.81	18	2.86	**17**
Poor contract documentation	2.67	22	2.84	16	2.78	**18**
Ineffective decision making	2.56	24	2.81	19	2.75	**19**
Time boxing (limited duration)	3.00	9	2.55	23	2.66	**20**
Poor communication	2.70	19	2.65	20	2.66	**21**
Workers emotional and psychological attitudes	2.60	23	2.63	22	2.63	**22**
Uncertainty (weather, soil etc.)	2.90	15	2.45	27	2.56	**23**
Inappropriate use of tools/equipment	2.70	19	2.52	24	2.56	**24**
Poor leadership	2.20	28	2.65	21	2.54	**25**
Procurement errors	2.50	25	2.52	25	2.51	**26**
Misunderstandings	2.40	26	2.48	26	2.46	**27**
Untimely deliveries of materials	2.40	27	2.45	27	2.44	**28**

Except for design/construction changes that is significant among the causes of rework, other causes were only moderately significant. However, a close examination of the highly rated causes shows that they are mostly related to design. They do not only top the table, they also constitute one-third of the causes of rework in residential buildings. The implication of this result is that, about 34% of the significant causes of rework in residential buildings are related to design problems. Also, Table 2 shows that, complicated construction programs, change in method of construction, lack of coordinator and planning, omission, poor construction management policies and time boxing are the causes of rework in public residential buildings. The private residential buildings have wrong/defective materials, quality deviations, non-conformance and inadequate supervisory/management skills as the causes of rework. This shows that the causes of rework in public buildings are not the same with the causes of rework in private buildings.

Table 3 indicates the cost implication of rework on the budgeted cost of residential building projects investigated in the study. The result shows the initial contract sum, cost of rework, sum of initial contract sum and rework cost and the percentage rework cost of the buildings. The average percentage rework cost of residential buildings from Table 3 is 10.28%. The value, 10.28% is not only too high for rework cost, it is stunning to see some residential buildings like numbers 3, 6, 17, 28 and 29 with rework costs of 36.7%, 44.68%, 22.24%, 35.09% and 18.96% respectively.

In the same vein, buildings 2, 14, 15, 18, 20, 30, 32 and 39 have rework costs of 10.59%, 15.10%, 15.66%, 13.29%, 10.01%, 10.83%, 13.34%, and 13.76% respectively. Thus, if rework can be effectively contained, there can be about 10% reduction in the total cost of construction and this will reduce the selling price of such buildings.

Table 3: Cost implication of rework on residential buildings

S/N	Initial Contract Sum (million)	Initial contract sum plus rework cost (million)	Cost of Rework	Percentage Rework cost
1	365,800,735.00	372,350,835.00	6,550,100.00	1.79
2	51,886,879.00	57,383,551.00	5,496,672.00	10.59
3	647,000,000.00	884,450,000.00	237,450,000.00	36.70
4	112,000,000.00	112,000,000.00	0.00	0.00
5	1,001,120,000.00	1,068,145,121.00	67,025,121.00	6.70
6	74,776,450.00	108,188,250.00	33,411,800.00	44.68
7	45,200,000.00	46,000,000.00	800,000.00	1.77
8	7,666,883,924.11	8,111,219,787.25	444,335,863.14	5.80
9	45,200,100.00	46,000,000.00	799,900.00	1.77
10	175,000,000.00	175,000,000.00	0.00	0.00
11	129,036,594.00	132,061,667.00	3,025,073.00	2.34
12	190,010,263.00	196,910,263.00	6,900,000.00	3.63
13	82,609,061.00	84,929,061.00	2,320,000.00	2.81
14	2,112,884,778.00	2,443,778,224.00	330,893,446.00	15.66
15	704,711,000.00	811,161,000.00	106,450,000.00	15.11
16	175,000,000.00	175,000,000.00	0.00	0.00
17	900,995,298.90	1,101,400,729.19	200,405,430.29	22.24
18	729,426,736.00	826,358,480.00	96,931,744.00	13.29
19	366,494,467.00	366,494,467.00	0.00	0.00
20	611,314,616.00	672,531,702.00	61,217,086.00	10.01
21	127,000,000.00	129,500,000.00	2,500,000.00	1.98
22	33,424,290.72	33,424,290.72	0.00	0.00
23	673,769,850.00	731,767,997.00	57,998,147.00	8.61
24	73,812,465.00	74,112,465.00	300,000.00	0.41
25	894,600,000.00	927,024,300.00	32,424,300.00	3.62
26	79,359,237.00	79,659,237.00	300,000.00	0.38
27	101,065,935.00	101,065,935.00	0.00	0.00
28	832,000,000.00	1,123,965,120.00	291,965,120.00	35.09
29	487,500,000.00	579,950,000.00	92,450,000.00	18.96
30	136,410,080.00	151,186,116.00	14,776,036.00	10.83
31	95,692,382.00	98,616,506.00	2,924,124.00	3.06
32	732,100,978.00	829,773,740.00	97,672,762.00	13.34
33	582,426,736.00	587,643,936.00	5,217,200.00	0.90

34	187,000,000.00	187,000,000.00	0.00	0.00
35	3,424,290.72	3,424,290.72	0.00	0.00
36	85,812,060.00	88,132,060.00	2,320,000.00	2.70
37	78,456,357.00	85,274,354.00	6,817,997.00	8.69
38	45,200,100.00	46,000,000.00	799,900.00	1.77
39	98,774,635.00	112,365,432.00	13,590,797.00	13.76
40	82,908,061.00	84,929,061.00	2,021,000.00	2.44
41	77,653,237.00	79,659,237.00	2,006,000.00	2.58
	21,695,741,596.45	**23,925,837,214.88**	**2,230,095,618.43**	

21,695,741,596.45 23,925,837,214.88 2,230,095,618.43

$$\textbf{Percentage of rework costs} = \frac{\text{Rework cost}}{\text{initial contract sum}} \times 100 = \frac{2{,}230{,}095{,}618.43}{21{,}695{,}741{,}596.45} \times 100\% = 10.28\%$$

Table 4 presents the result of the respondents' perception on the elements that contribute the most to the cost of rework. Result indicates that substructure (3.61) contributes the most to rework cost followed by electrical installation (3.29), mechanical installation (3.27), frames and upper floor (3.15), finishes (3.15), and roof covering (3.15). Therefore, to minimize rework cost, rework must be minimized to the barest minimum in substructure, electrical installation, mechanical installation, frames and upper floors, finishes, and roof covering. It differs when private buildings were considered separately as they rated substructure (3.50) as the highest contributor to rework, followed by mechanical installation (3.20), finishes (3.10), external works (3.10), roof covering (3.00), electrical installation (2.90), frames and upper floors (2.80), walls (2.40), doors and windows (2.40), furniture's and fittings (2.40), and painting (2.40).

The rating of the public buildings is similar to that of the combined rating except in the case of finishes, roof covering, walls, external work, windows, fitting and painting. It is expected that, substructure constitutes huge rework cost because many designers do not visit sites before designing for foundation of buildings. In fact, some do not conduct soil test before recommending foundations to clients. Also, mechanical and electrical works take key positions in contributing to rework cost because their costs are mostly based on provisional sums in Nigeria, and this constitutes a huge ambiguity to construction cost. Finishes usually consists of variations due to clients not making up their mind on the type of finish to use on their buildings.

Table 4: Contribution of building elements to cost of rework

Building elements	Public Mean	Rank	Private Mean	Rank	Total Mean	Rank
Substructure	3.50	1	3.65	1	3.61	1
Electrical installation	2.90	6	3.42	2	3.29	2
Mechanical installation	3.20	2	3.32	3	3.27	3
Frames and upper floors	2.80	7	3.26	4	3.15	4
Finishing	3.10	3	3.16	6	3.15	5
Roof covering	3.00	5	3.19	5	3.15	6
Walls	2.40	8	2.97	7	2.83	7
External works	3.10	3	2.71	11	2.80	8
Doors and windows	2.40	8	2.90	8	2.78	9
Furniture and fittings	2.40	8	2.87	9	2.76	10
Painting	2.40	8	2.83	10	2.73	11

Table 5 shows the importance of the methods of reducing the effect of rework on the cost of building projects. Supervision of project was rated with 3.76, followed by co-ordination of project (3.44), standardization of project (3.34), effective quality control plan (3.44), effective design management (3.34), control of the flow of information (3.32), adequate planning at inception (3.32), supervisors training (3.27), use of information technology (3.24), standard project management procedure (3.10), and unvaried project scope (3.00).

For the public buildings, the most important methods of reducing rework are; having order of information flow, proper supervision of projects, co-ordination of projects, effective quality control plan, effective design management, standardization of construction project, standard project management procedure, and adequate planning at inception among others.

Test of hypothesis 1

$H_{1\ null}$: There is no significant difference in the causes of rework between public and private residential buildings

$H_{1\ alternative}$: There is significant difference in the causes of rework between public and private residential buildings

Table 6 shows the difference in the causes of rework between public and private residential buildings. This difference was determined with t-test statistics and P-values of the causes of rework investigated in this study. The result shows that, there is no significant difference in the causes of rework between public and private residential buildings (P-values exceed 0.05) Hence, the causes of rework in public residential buildings are not significantly different from those of private residential buildings.

Table 5: Methods of reducing rework in public and private residential buildings

Methods of minimizing rework	Public Mean	Rank	Private Mean	Rank	Total Mean	Rank
Supervision	3.70	2	3.77	1	3.76	1
Coordination	3.50	3	3.42	2	3.44	2
Standardization	3.40	6	3.32	3	3.34	3
Effective quality control plan	3.50	3	3.29	6	3.34	4
Effective design management	3.50	3	3.29	6	3.34	5
Control of the flow of information	3.80	1	3.16	9	3.32	6
Adequate planning at inception	3.30	8	3.32	3	3.32	7
Supervisors training	3.10	10	3.32	3	3.27	8
Use of information technology	3.30	8	3.23	8	3.24	9
Standard project management procedure	3.40	6	3.00	10	3.10	10
Unvaried project scope	3.10	10	2.97	11	3.00	11
Ensure sustained user involvement	2.70	13	2.97	11	2.90	12
Establishing system design	3.00	12	2.87	13	2.90	13

Table 6: Difference in the causes of rework between public and private residential buildings

Causes of rework	df	F	P-value	Significance	Decision
Design/construction changes	39	1.723	0.197	Not significant	Accept Ho
Defects in building	39	0.353	0.556	Not significant	Accept Ho
Design errors	39	0.134	0.716	Not significant	Accept Ho
Quality failure	39	0.216	0.645	Not significant	Accept Ho
Incompetent supervisors	39	0.412	0.525	Not significant	Accept Ho
Poor workmanship	39	0.254	0.617	Not significant	Accept Ho
Wrong materials/defective materials	39	0.385	0.539	Not significant	Accept Ho
Incomplete designs	39	0.414	0.524	Not significant	Accept Ho
Quality deviations	39	0.135	0.715	Not significant	Accept Ho
Damage	39	1.307	0.260	Not significant	Accept Ho

Non-conformance	39	0.697	0.409	Not significant	Accept Ho
Complicated construction program	39	0.414	0.524	Not significant	Accept Ho
Inadequate supervisory/managerial skills	39	0.061	0.807	Not significant	Accept Ho
Change in the method of construction	39	1.904	0.176	Not significant	Accept Ho
Lack of coordination and planning	39	0.028	0.867	Not significant	Accept Ho
Omission	39	0.875	0.355	Not significant	Accept Ho
Poor construction management policies	39	0.059	0.809	Not significant	Accept Ho
Poor contract documentation	39	0.263	0.611	Not significant	Accept Ho
Ineffective decision making	39	0.028	0.868	Not significant	Accept Ho
Time boxing (limited duration)	39	2.231	0.143	Not significant	Accept Ho
Poor communication	39	0.351	0.557	Not significant	Accept Ho
Workers emotional and psychological attitudes	39	0.284	0.597	Not significant	Accept Ho
Uncertainty (weather, soil etc.)	39	0.013	0.909	Not significant	Accept Ho
Inappropriate use of tools/equipment	39	1.899	0.171	Not significant	Accept Ho
Poor leadership	39	0.002	0.961	Not significant	Accept Ho
Procurement errors	39	1.545	0.221	Not significant	Accept Ho
Misunderstandings	39	0.014	0.908	Not significant	Accept Ho
Untimely deliveries of materials	39	0.291	0.593	Not significant	Accept Ho

Test of hypothesis 2

$H_{2\ null}$: There is no significant difference in the methods of reducing rework between public and private residential buildings

$H_{2\ alternative}$: There is significant difference in the methods of reducing rework between public and private residential buildings

Table 7 indicates the difference in the methods of reducing rework between public and private residential buildings. The result shows that in all cases, except effective quality control plan, there is no significant difference in the methods of reducing rework between public and private residential buildings ($P > 0.05$). The implication of the result is that, for both public and private residential buildings, the important methods of reducing rework on building projects are the same.

Table 7: Test of difference of the methods of reducing rework in public and private residential buildings

Methods of minimizing rework	df	F	P-value	Significance	Decision
Supervision	39	0.216	0.645	Not significant	Accept Ho
Coordination	39	0.137	0.714	Not significant	Accept Ho
Standardization	39	0.103	0.750	Not significant	Accept Ho
Effective quality control plan	39	5.520	0.024	Significant	**Reject Ho**
Effective design management	39	0.768	0.386	Not significant	Accept Ho
Control of the flow of information	39	0.827	0.369	Not significant	Accept Ho
Adequate planning at inception	39	0.871	0.356	Not significant	Accept Ho
Supervisors training	39	0.075	0.785	Not significant	Accept Ho
Use of information technology	39	0.260	0.613	Not significant	Accept Ho
Standard project management procedure	39	1.109	0.299	Not significant	Accept Ho
Unvaried project scope	39	1.372	0.249	Not significant	Accept Ho
Ensure sustained user involvement	39	0.006	0.941	Not significant	Accept Ho
Establishing system design	39	1.114	0.712	Not significant	Accept Ho

Discussion of Findings

The aim of this study was to reduce the rework cost of building projects by investigating the causes of rework, building elements that contribute the most to rework, the cost contribution of rework to building projects and the important methods of reducing rework on construction projects. The results of the study concur with literature (Love & Edward 2004; Love & Smith, 2003; Hwang *et al.,* 2009; Love *et al.,* 2004) that, design-related issues are the prominent causes of rework on the building projects.

In addition, the result of the study on the contribution of rework (10.31%) to the cost of building projects is similar to that of Josephson and Hammarlund (1999) that got 6% on commercial buildings, Barber *et al.* (2000) that got 6% in the United Kingdom, Love *et al* (2000) that got 12.4% in the United States and Burati *et al.* (1992) that got 12.4% on nine engineering projects. Love and Li (2000) found that, rework adds 3.15% to the initial contract sum of construction projects in Australia. Abdul-Rahman (1995) discovered that, rework increases initial contract sum of highway projects by about 5%. Therefore, the study concludes that, rework costs of construction projects (including buildings) range between 3 to 10% in many countries, depending on the accuracy of the designs (since designs are the major causes of rework) of such projects.

Moreover, the study of Oyewobi *et al.* (2011) indicate that substructure, frames, upper floor, doors, windows and finishing are the elements that have the greatest contribution to rework. In this study however, all the elements investigated have high contribution to rework except, doors and windows. The elements that contribute to rework cost of building projects are substructure, finishing, frames, and upper floors respectively.

Moreover, there is no significant difference in the causes of rework on public and private residential buildings. This is not a surprising result as, it is the same professionals that mostly design for both private and public construction projects. Hence, the same set of rules, norms and experience are expected to be applicable to all projects. However, there is significant difference in the quality control methods adopted for the execution of public and private building projects. This result is expected because public organisations appear to be more institutionalized in their approach to construction. Hence, it is expected that the quality control of public building projects will be significantly different from those of private building projects.

Conclusion and Recommendations

Based on the findings of this study, it was concluded that the causes of rework are mostly design-related and they include design changes, design errors, defects and quality failure among others. The study further concludes that the causes of reworks in public residential buildings are not significantly different from those of private residential buildings. In addition, the study concludes that rework may continue to add up to 10% of the agreed contract sum of building projects if its causes are not effectively mitigated.

Moreover, it can be said that, to mitigate the causes of rework there must be adequate supervision of construction projects, coordination of projects, standardization of work procedures, effective quality control and design management practice. The methods to be used for the reduction of rework on public residential building projects are the same as those to be used on private residential building projects. In addition, the study concludes that, substructure, mechanical and electrical installations, framing, and finishing are the elements that contribute the most to rework in residential building projects.

Based on these conclusions, the study recommends that, contract documents should be given adequate attention during design so that rework can be minimized to the barest minimum. The study further recommends that, designers should visit sites before recommending any type of substructure for buildings. Projects should also be supervised and coordinated by experienced personnel.

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