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Full Length Research Paper

Evaluating rework cost- A study of selected building projects in Niger State, Nigeria

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Rework represents a new terminology in construction dictionary and it becomes essential when an element of building works fails to meet customer's requirement or when the completed work does not conform to the contract documentation. Reworks contribute to time and cost overruns in project. Thus, to enhance efficient project delivery processes the research work evaluated rework cost on elemental basis in some selected building projects in Niger State. Archival cost data were sourced using a structure research schedule which was self administered on projects identified to have experienced rework amongst the selected projects and these were analysed using simple percentile to show at a glance contribution of each of the building elements to rework. The study revealed Finishes (19.09%) have higher contribution to rework costs than any other elements of building for the projects considered and rework costs on average for the elements 4.49%. Hence, there is need for consensus on a workable mechanism to bring together the client and the contractor to minimize change orders and introduction of additional works during construction phase as this would lead to a reduction in the occurrence of reworks as revealed by the research.

Key words: Rework, cost overruns, time overruns, building projects.

INTRODUCTION

The construction industry plays a major role in national development. In the 1980s it was one of the contributors to the GDP (National Construction Policy, 1989) while in 2007 its contribution dropped to 1.72% of the GDP (Federal bureau of statistics, 2007). This is an abnormal curve in term of performance and an indication of an ailing industry which demands attention of the stakeholders. Olomolaiye (1990), Aniekwu (1995), Okuwoga (1998) and Oladapo (2007) attributed this to poor performance, low demand and low productivity. Hence, there is need to improve the performance of the industry and enhance its contribution to the GDP which is tending towards zero by given the required attention to solving the problems of the industry.

Cost and time overruns have become a cankerworm within the Nigerian construction industry today as well as lack of good quality work of its end product which do not provide many of the clients' value for money. Constructions projects in Nigeria are known for over-shooting their initial cost budget, which invariably means it is out of initial time schedule (Okpala and Aniekwu, 1988; Elinwa and Buba, 1993; Kaming et al., 1997; Achuenu, 1999; Elinwa and Joshua, 2001; Bali and Price, 2003; Ogunsemi and Aje, 2005). Rework was viewed by (Chan and Kumaraswamy, 1997; Thomas and Neapolitan, 1994; Love, 2002a) as contributor to cost and time overruns in project delivery process. However, rework in a construction process has been seen as a wasteful activity, because, it is brought about by inefficiency which results in the use of resources in larger quantities than those considered necessary (Koskela, 1992, 1993). The Construction Industry Institute (2001), viewed rework as: "activities in the field that have to be done more than once in the field or activities that remove work previously installed as part of the project"(p.153). Rework may occur in any conceived project at both the design and construction stages and it may be in the form of variation, non-variation or design error or omission. Therefore, this research paper evaluated rework cost of selected building projects with a view to enhancing effective project delivery in Nigeria. By evaluating rework cost, it is envisaged that it will give the construction professionals and clients better understanding or create an early warning on the effect of reworks on project

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delivery. It is believed that understanding of this will promote and enable client identify effective prevention strategies that can be implemented to improve project performance in term of cost, time and quality. This research paper contributes to the study of quality and value for money in construction by identifying factors that lead to rework and therefore affect effective project performance.

REVIEWED LITERATURES

Problems in the Nigerian construction industry

Construction is heavily dependent upon business cycles. Changes in interest rates to two digit figures, tax laws and eventual hike in value added tax in 2007, which was later reverted, affect individual and business decisions related to construction activity. State and local budgets affect road construction and maintenance. Changes in regulations can result in new construction or stop planned projects. The effects of these various influences can be short term or long term.

The growth of construction industry in Nigeria in the past two decades indicates its success in contributing to the country's Gross National Product, which was 1.72 in Year 2007 (Federal bureau of statistics, 2007). This industry sector is the second most important for absorbing human resources after the food. In the 1990's, approximately 2.5 million labourers were involved directly in construction projects. However, 88% are unskilled or have low levels of skill, 11% have medium to high levels and the rest (1%) are at managerial levels. The large range in this organisational structure is still indicated as a serious problem in Nigeria as a developing country. In other words, the construction industry is facing a serious labour skills shortage. Young people are not keen to work in this industry. This is because construction jobs in Nigeria tend to rely on physical work or hard manual labour and offer relatively poor pay conditions. Even when they do, most of them do not receive proper training before entering the construction site and they work as unqualified and unskilled labourers. As a result, extra coordination and supervision is required for the workers. This situation also is often related to productivity problems Olomolaiye (1990), Aniekwu (1995), Okuwoga (1998) and Oladapo (2007) and the consequences are reworks or outright demolition of constructed parts that do not conform to drawings.

Due to the improved procurement systems in the 2000's, the Nigerian people are demanding better service from the construction industry, and contractors are facing tremendous pressure to increase construction productivity and clients' requirement becomes more sophisticated The projects undertaken have grown in size, design complexity and construction difficulty. Nonetheless, the development cycle has been shortened as a means of reducing the overall cost of development and occurrence of reworks or change orders. The traditional approach of having design fully completed before construction works begin can no longer meet the needs of clients because of its inherent delay and cost overrun. Various procurement options have therefore been developed to satisfy the needs of the industry and consequently proffer solutions because of the nature of the industry but to reduce the upsurge of construction cost caused by improper documentation or design errors.

Causes of rework at the design-construction interface

Generally, it is during the execution phase of the projects where design defects are detected which consequently leads to rework; the problems associated with the designs as viewed by Alarcon and Mardones (1998) are mainly:

(i) Design quality: Design drawings are generally incomplete and they are not explicit, requiring a great amount of specifications. Specifications are difficult to handle and sometimes are ignored. Very often design documents have inconsistencies, errors and omissions, or simply lack of clarity in the presentation. This implies that those that should carry out the work do not have the necessary information or have the wrong information to do the job which may cause total rework or outright cancellation.
(ii) Design standards: There is a lack of standards in the designs, and lack of suitability for the existing technology. In many projects of similar characteristics, or of the same type, the designs used are completely different with the consequent loss of efficiency in the construction phase.
(iii) Constructability: An important proportion of the problems detected during construction are due to lack of constructability of the designs. Details not defined in the designs become problems that have to be solved by the contractor on site. Usually the problems are detected just before starting construction of the specific task and sometimes even after the task has been accomplished. The results (lack of constructability of the designs) are a loss of different type and magnitude which in returns increase the cost of doing the work and invariably affects its delivery period.

Methods of reducing rework at design-construction interface

Alarcon and Mardones (1998) designed some methods that could be used to eliminate the causes of the defects detected in the identification phase of building construction projects. These problems can be solved through four different actions;

(i) Supervision of the design process, a construction

Table 1. Elements of building and their contribution to reworks.

Elements	Initial cost	Additional works cost	Rework cost	variation cost	Final cost	% of rework cost in variation cost	% of rework cost in final cost	Cost overrun
Substructure	240.38	11.77	6.8	18.57	258.95	36.62	2.63	18.57
frames and upper floors	172.38	10.64	7.36	18	190.38	40.89	3.87	18
Roof and covering	165.86	6.98	2.05	9.03	174.89	22.70	1.17	9.03
Wall	118.97	3.23	3.53	6.76	125.73	52.22	2.81	6.76
Doors and Windows	75.56	8.67	4.03	12.7	88.26	31.73	4.57	12.7
Furniture and Fittings	20.2	3.46	3.49	6.95	27.15	50.22	12.85	6.95
Mechanical installation	45.11	1.99	5.38	7.37	52.48	73.00	10.25	7.37
Electrical installation	69.21	1.46	0.85	2.31	71.52	36.80	1.19	2.31
Finishing	183.16	25.84	8.65	34.49	217.65	25.08	3.97	34.49
Painting	59.41	1.71	1.98	3.69	63.1	53.66	3.14	3.69
External works and drainage	38.45	0.06	1.18	1.24	39.69	95.16	2.97	1.24

company must participate in the design process, in order to avoid the problems related to lack of construction knowledge of the designers, providing its experience in design solutions.
(ii) Coordination of the different specialties through a logic sequence of information transfer, avoiding incorrect assumptions, and giving a priority level for changes in order to avoid lack of coordination and to improve the design compatibility;
(iii) Standardization of design information, to avoid the omissions, errors and continuous changes, those affect the normal development of the projects.
(iv) Control of the flow of information, verifying that the requirements of previous processes are fulfilled, in order to avoid that design defects arrive to the construction site.

METHODOLOGY

The methodology adopted by this research was data collection procedure through research schedule. The researcher designed the research schedule to source for information relating to project specifics. These include the facility type, type of project and project characteristics such as estimated contract sum, revised contract sum and rework cost (change orders or variation that involves reconstruction which the researcher extracted personally). It also includes the initial and the final duration of the project as well as the year of award of the contract. The researcher personally source cost data on the selected projects from the participants on the projects using the developed research schedule and this was done by making use of the hard copy of all the valuations carried out on any selected project up to penultimate valuation including the final account summary of the selected projects. Cost data of the selected projects were sought for and their characteristics recorded appropriately. It becomes essential to state that this research was limited to Federal Government executed building projects (institutional projects) in Niger State, Nigeria between 1999 and 2008. This is because Government is the main customer or initiator of public projects. The data collected was analyzed using percentiles and Pearson product moment correlation coefficient.

The correlation co-efficient (r)

This measures the strength of the relationship between the dependent and independent variables that is among rework cost, Initial contract sum, variation costs and time overrun. This statistical technique measures the degree of closeness or relationship between the variables. Mathematically it is expressed as:

$$R = \frac{\sum X_i Y_i - nXY}{\sqrt{[(\sum X_i^2 - nX^2)(\sum Y_i^2 - nY^2)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Determinant R = - 1<r<+1
R = + 1.00 (direct correlation)
R = 0.00 no relationship
R = - 1.00 inverse relationship
The nearer R approaches 1, the greater the degree of relationship; and the more it approaches zero, the less the degree of relationship.

ANALYSIS AND RESULTS

Table 1, shows the elemental cost of the selected 25 institutional building projects, total variation cost and total rework cost of each of the elements. The final elemental cost of the projects was computed by summing up the elemental cost and variation cost together as well as cost overrun. Percentage of rework in variation and final cost of each element was also determined to enhance better understanding of the contribution of each of the elements to rework cost. From Table 1, finishes was observed to have highest rework cost of ₦8.65M and electrical installation rework cost of less than ₦1million (₦0.85million). This indicates that rework occurred mostly in finishes followed by frame with ₦7.36million rework cost for the projects due to technical factors. In considering the percentage of rework cost in final cost

Table 2. Relationship between rework costs, variation cost and time overrun.

	Rework	Initial	Variation	Time overrun
Rework	1	0.620**	0.854**	0.473*
Initial	0.620**	1	0.654**	0.554**
Variation	0.854**	0.654**	1	0.718**
Time overrun	0.473*	0.544**	0.718**	1

per each of the elements, fittings and fixtures showed the highest percentage of 12.85% meaning that 12.85% of the total cost of this element constitutes rework cost. In the same vein, 10.25% of the total cost of providing mechanical installation for the entire 25 projects under consideration was expended in redoing what has been done before because of non conformance to client's requirement. Finishes has the highest contribution to the cost overrun experienced by the selected projects, ₦34million of the total cost overrun originated from error traceable to poor finishing with electrical installation having the lowest contribution of ₦2.31million, this means electrical work hardly experience rework except in a case of faulty design.

Relationship between rework cost, variation, time overrun and initial contract sum

Table 2 shows the result of analysis carried out to test whether there was significant relationship among the variables tested (rework cost, initial contract sum, variation costs and time overrun); Pearson's (r) correlation was calculated. The correlation coefficient for the data revealed that variables tested were significantly related. The result of the correlation between initial construction cost for all the projects, cost overrun and time overrun of the buildings for the twenty-five projects considered were significant at 1%, except the relationship between rework costs and project time overrun which was significant at 5%. The significant relationship was demonstrated by correlation between rework cost and cost overrun (variation) with the values of $r=+0.854$, $n=25$, $p<0.01$, also, correlation between cost overrun and time overrun is shown with the values of $r=+0.718$, $n=25$, $p<0.01$. Hikkles et al. (1998) recommended that correlation in the range of 70 (0.70) to 90% (0.90) is high and 50 (.50) to 70% (.70) is moderate. This rule is pertinent in this respect since r- value is used in determining the strength of the relationship, which indicates that an increase in one variable give rise to a corresponding increase in the other (Love, 2002). Thus, the correlation between reworks costs and cost overrun is high because 85.4% means that there is a positive high correlation between the variables. Therefore, as the rework cost slopes from left to the right the cost of variation also increases.

The correlation analysis also revealed that rework costs and time overrun of the project are significantly related, $r=+0.473$, $n=25$, $p<0.05$. However, the r (47.3) value is low considering the recommendation given by Hikkles et al.(1998) as stated above, which means the more the occurrence of rework the more the increase in time for rectifying the defects.

DISCUSSION OF RESULTS

From the sought information on a total number of 25 selected institutional building projects and which was duly analysed, it was found out that virtually, all the elements of the projects overrun their initial cost with an average percentage cost-overrun of about 9.09%. This was corroborated by the opinions of the previous researchers on time and cost performances of building projects in Nigeria. They agreed that projects are known for overrunning both their initial time and cost budget in Nigeria (Okpala and Aniekwu, 1988; Elinwa and Buba, 1993; Achuenu and Kolawole, 1998; Achuenu, 1999; Aibinu and Jagboro, 2002; Ogunsemi and Jagboro, 2006; Ogunsemi, 2002). The final cost of the 25 selected building projects on elemental basis was ₦1, 309,800,000 whereas N45, 300, 00.00 constituted total rework cost, corresponding to 4.49% of the estimated final construction cost of the whole selected projects. Egan (1998) reported that rework cost in building projects could be as high as 30% this was corroborated by Cnuddle (1991) who reported cost of non-conformance to between 10 to 20% of total project cost and Burati et al. (1992) who posited that cost of quality deviation (rework) could be as high as 12.4%.

Hammarlund et al. (1990) also reported 11% but Harmmarlund and Josephson (1991) reported 4% of the total project cost, while Love (2002) reported 6.4% as the mean value of direct cost of rework. From the analysis of the selected building projects, cost of rework was found out to be as high as 9.88% of the cost of a project, which has been previously argued by Love (2002a) that some projects are capable of showing high cost of rework costs. On the average for the entire projects considered, total rework costs was 4.49%, this result was not too far from 2.3 to 9.4% of contract value reported by Harmmarlund and Josephson (1991). The result showed that the average rework costs of the selected projects

were lower than what has been reported in Australia (Love, 2002), in Indonesia (Alwi, 1995) and Sweden (Harmmarlund and Josephson, 1991).

The result of the correlation between initial construction cost of all the projects, cost overrun and time overrun of the buildings for the twenty-five projects considered were significant at 1%, except the relationship between rework costs and project time overrun which was significant at 5%.

Conclusions

It is necessary to note that this research work centred on evaluation of rework costs identifiable in some selected building projects. Therefore, the analysed effects of rework on project performance by the research were done to give an insight into the likely final contract sum of projects if rework is identified. Thus, it was concluded that:

1. The average percentage of rework costs on elemental basis could be as high as 5.29% as against 3.47% recorded on the entire project considered.
2.The analysed contributory effect of building elements to rework in term of cost and time indicates that finishes (19.09%) is more prone to rework which may be due erroneous workmanship, poor machine or tools handling or mistakes in material selection
3. The findings also showed that positive relationship do exist between rework costs and variation cost as well as between rework costs and time overrun. This implies that an increase in rework cost will give rise to an increase in variation cost as well as increase in project duration.

It was recommended that a quality assurance mechanism is required to be established to enhance and ensure buildability of quality designs by encouraging early involvement of contractors at the design stages to reduce design errors or mistakes in the design with consequential effects of rework.
Also, if rework in construction has to be reduced or eliminated there is need for consensus on a workable mechanism to bring together the client, consultant and the contractor to minimize change orders and introduction of additional works during construction phase.

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