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Effect of Rework on Project Performance in Building Project in Nigeria

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***Abstract* — Rework occurs as a result of design, construction changes and also as variation which is addition, omission and modification of design. Rework cost is on the increase as a result of these changes and it has indirectly affected contract sum, period of completion and quality of the project. Hence this study intends to examine the causes and effects of rework in building projects. Descriptive research design was used for this study and the population consists of construction professionals from consulting and contracting organization. Simple random sampling technique method was used. A structured questionnaire was used as the principal instrument for collecting data from construction professionals in the industry. A total of 98 questionnaires were distributed and 52 were returned given an average response rate of 52%. Statistical package for social sciences (SPSS) 17th version was used for analysis via descriptive and inferential statistic. The findings of the study indicates that changes, defect and quality deviation are the most significant sources of rework on construction projects. Poor communication with design exerts the greatest influence on the rework occurrence on construction sites. The paper also showed that there is significant relationship between rework cost and initial contract sum, initial and final contract period, with exception of final contract sum. In conclusion poor communication with design consultant, use of poor quality materials and poor workmanship are the main causes of reworks in building projects, hence this will affect the client and the project performance in terms of time, cost and quality standard. The study recommends that early identification of the causes and sources of reworks by consultants and contractors on building projects will reduce the effect of reworks cost on the contract sum, completion time and changes during the design and the construction changes either from the part of the client or the consultant.**

Keywords* — *Change, cost and time overrun, performance, project, reworks

I. INTRODUCTION

The construction industry plays a major role in national development. Increased construction activities have led to increased economic activities on the path to economic development. In 2012, Building and construction sector was rated amongst the fastest growing sectors amongst the components of Nigeria GDP with a growth rate of 12.53% [1]. The report also showed that the sector recorded 2.19% contribution to the GDP in the year ending 2012. The figure depicts the ailing nature coupled with the poor performance of the industry which demands urgent attention from stakeholders. In a research carried out by [2], he attributed the low contribution of the industry to the economy to poor performance, low demand and low productivity. There is need for improvement of the industry by addressing industry issues and solving the problems which will result into enhanced contribution to the economy.

Cost and time overruns as well as poor quality of construction work have become the biggest cankerworm which has eaten deep into the fabric of the construction industry. Different researchers [3, 4, 5] have buttressed the fact that construction projects in Nigeria are known for cost escalation from their initial cost budget, ultimately leading to increased time for completion. The construction products do not represent the clients' true value for money. Reference [6, 7] highlighted rework as a significant factor responsible for cost and time overruns in project delivery process. Quality of work is verified by regular inspections of the project's supervisor. Unfortunately the quality is not always as desired and work has to be redone, which has a negative effect on the project schedule and costs [8].

When construction products do not meet the requirements or expectations, work often has to be redone. Rework occurs in various phases of the construction process or in various divisions of a company. Rework can occur on the construction site due to bad materials management amongst other reasons. Rework is an effort of redoing an activity that was incorrectly implemented the first instance as a result of errors or omissions during design and construction. Reference [9] cited in [10] defined rework as "activities that have to be done more than once or activities that remove work previously installed as part of a project". Reference [11] cited in [7] also defined rework as "the process by which an item is made to conform to the original requirement by completion or correction". Rework is a problematic issue in construction projects [12, 13, 14].It has contributed to latent conditions in organizational and project systems [13]. Annual loss due to rework could be as high as US$15billion for industrial construction projects.

Although changes are inevitable in construction projects, uncontrolled occurrence of rework and wastage

should be controlled in order to improve client's objectives in terms of cost targets, timeliness and product service quality. According to [15], the project manager plays the significant role in ensuring a balance of competing demand of quality, scope, time and cost. The effective management of project provides the fulcrum of tracking rework occurrences thereby implementing suitable management measures on resultant impacts on productivity and performance [16].

Reference [17] opined that knowing and understanding rework causes can provide the basis to stimulate learning within the project environment especially when litigation proceedings have been enacted. It is against this backdrop that this research paper intends to examine the causes, sources and effects of reworks on project performance, thereby contributing to the enhancement of the attainment of value for money.

II. LITERATURE REVIEW

In a study by [18] on evaluating rework, in middle central part of Nigeria it was realized that all the element of the building had a direct bearing on an increase in final cost of the project as a result of rework. From their study finishes is more prone to rework as a result of erroneous workmanship, poor machine or tool handling or mistakes in material selection and the least element prone to rework is electrical installation. Additional rework cost as lead to cost overrun which is a common phenomenon in Nigeria building projects as opined by [19] and [20]. It implies that reworks contribute to time and cost overruns in construction projects. There is also a positive relationship between rework and variation or change order. Changes in construction project cause rework which lead to cost overruns and delays. It could be the responsibility of the owner, designer, contractor or a third party.

Reference [21] studied the impact of changes on project productivity and found that late changes have a high impact on productivity of an project. He therefore said early changes should be encouraged and late changes should be discouraged. Reference [12] opined that contract document causes rework due to lack of experience of the design team and inadequate time to study the document. Also poor coordination within the design process could contribute to occurrences of service clashing among the stakeholders.

Communication among the parties involved in the project is a factor that cause rework in construction project. According to [22], poor communication between the clients, designer and consultants leads to rework because most clients are not experienced in design and construction process. The communication gap between the client, consultants and contractor most times result in defective work; leading to the construction work been carried out again.

Design management also contributes to rework. Reference [12] identified strategies for design management which include value management, design for construction, computer visualization, subcontractor/supplier involvement in design, constructability analysis, design scope freezing and team building. Value management is a technique used for reevaluation of the functionality and client's requirements to reduce the clients' changes during construction which may lead to rework. Also ineffective use of information technology by design team for purpose of communication and coordination could lead to rework.

Rework has adverse effects on the performance and productivity of building and civil engineering projects. It led to cost and time overruns of procurement process in construction [22].In their study on benchmarking of reworks in Swedish, it was realized that cost of rework was 4.4% of the construction values of the observation period and the time needed to correct them was 7.1% of the total work time. Also in a study by [16] in Hong Kong, Artificial Neural Network (ANN) was used to map the causes and effects of rework. Finding according to them shows that ANN analysis indicates the genera regression neural network architecture is better suited for modeling rework causes and their impacts on project performance (cost overrun, time overrun, contractual claims).

Reference [24] found that 79% of rework costs arose in industrial engineering projects due to design changes, errors and omissions. The costs of rework have been found to range from 5-20% of contract value [25]. The rework cost is increasing at an alarming rate, albeit it is expedient to note that the figure might be higher, considering many construction practitioners do not keep records of the cost of carrying out construction activities more than once. According to [26], the consequence of rework on construction cost cannot be ascertained. However he was able to use a case study to demonstrate the indirect consequence of rework on cost. It was view from individual level, organization level and project level. He concluded that to reduce cost, design and construction organization must improve their quality management systems by auditing, analyzing and presenting direct and indirect rework costs. Rework does not only affect cost and time but also have a negative influence on intra and inter-organisational relations and the psychological well being of individuals (Love and Edwards, 2004). Rework also affect quality through the negative effect on any of its subcomponents (Chan and Tam, 2000).

III. RESEARCH METHOD

The research was conducted by an examination of relevant literature followed by administration of structured questionnaires used as a principal instrument to construction professionals in the consulting and contracting organisation. Random sampling technique method was used to select the population. A closed ended questionnaire was used to sought the opinion of the construction professional on their personal data and to obtain information on reworks based on past project handled. The questionnaire used a five point likert scale to measure a range of opinion from "strongly disagree" to "strongly agree". 98 copies of the prepared questionnaires were distributed, 52 completed copies were returned and used for the analysis. The average response rate to the questionnaires was pegged at an average of 52%. This response rate is considered adequate as according to [2] for researches in this part of the world. A descriptive

research design is used for this study. The data were analysis using Social Statistic for Social Sciences (SPSS) package 17th edition. The statistic tools used are descriptive statistic via percentage, ranking, average percentage, regression and mean item score (MIS) was used to analyze the data using this formula:

$$MIS = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + n_1}{5(n5+n4+n3+n2+n1)}$$

Where: N5=no of respondents with strongly agree;

N4= no of respondents with agree

N3= no of respondents with undecided;

N2= no of respondents with disagree

N1= no of respondents with strongly disagree

IV. RESULTS AND DISCUSSION

Descriptive data generated from the study questionnaire are reported in this research. Table 1 shows the summary of the demographic characteristics of the respondents. Senior/associate partner of their respective organization constitute the highest proportion (24%) of the respondents. 20% are project manager, 9% are head of department and only 7% are chief executive officer. It shows that the respondents are knowledgeable to provide adequate information in response to the questionnaire. A sizeable proportion (40%) of respondents is within the age bracket of 31-40years; while a meager 2% of the respondents are above 50years of age. 100% of the respondents received formal education, which put them in the right stead to provide valuable information for the research. As shown in Table 1, about 61% of respondents have working experience of 11years and above which implies that they are sufficiently knowledgeable in construction matters to take active part in construction process. Quantity Surveyors constitute 77% of the respondents- the highest proportion, indicating their involvement in cost associated matters such as rework on construction site. 70% are registered members of Nigeria Institute of Quantity Surveyor (NIQS), 10% are member of Nigerian Society of Engineers (NSE), 7% are member of Nigerian Institute of Builders (NIOB) and 3% are member of Nigerian Institute of Architects (NIA). 65% are corporate member of their professional institute. Majority of the respondents (67%) are from medium sized organization and 58% of this organization are consulting firms.

TABLE I. DEMOGRAPHIC INFORMATION OF RESPONDENTS

	Background information	***Frequency***	***Percentage %***
	Designation of respondent (N=46)		
	Chief executive officer	3	7
	Senior/associate partner	11	24
	Project manager	9	20
	Head of department	4	9
	Other	19	40
	Age of respondent (N-52)		
	Less than 20years	4	8
	21-30years	18	34
	31-40years	21	40
	41-50years	5	10
	51-60years	2	4
	Above 60years	2	4
	Highest academic qualification (N=52)		
	HND/B.Sc./B.Tech.	29	56
	PGD.	1	2
	M.Sc./MBA	22	42
	Professional qualification (N=42)		
	NIA	1	3
	NIOB	3	7
	NIQS	30	70
	NSE	4	10
	Others	4	10
	Status of membership (N=41)		
	Graduate	14	35
	Corporate	27	65
	Years of experience in construction (N=52)		
	1-10years	15	29
	11-20years	31	60
	21-30years	4	7
	41-50years	2	4
	Professional background (N=51)		
	Architect	1	2
	Quantity surveyor	40	77
	Builder	6	12
	Civil Engineer	2	4
	Mechanical Engineer	2	4
	Type of organization (N=52)		
	Contracting	19	37
	Consulting	30	58
	Client	3	5
	Size of organization (N=52)		
	Small	9	17
	Medium	35	67
	Large	8	16

Sources of rework

Table 2 presents the various sources of rework. The respondents were told to rate their level of agreement of sources of rework in a likert scale of 1-5.The mean score was calculated and rank accordingly as shows in table 2.The most rate sources of rework are changes(mean=4.06), defects (mean=3.77),quality deviation(mean =3.61),poor workmanship and inadequate supervisory/managerial skills (mean =3.41),errors (mean =3.39), wrong/defective materials(mean =3.35), damages(mean =3.31).The least rated sources of rework are omission(mean =2.96) and improper work protection(mean =2.80).

TABLE II. SOURCES OF REWORK

S/N	Sources of rework		
		MIS score	***Rank***
	Changes	0.81	1
	Defects	0.75	2
	Quality deviation	0.72	3
	Poor workmanship	0.68	4
	Inadequate supervisory/managerial skills	0.68	4
	Errors	0.68	6
	Wrong/defective materials	0.67	7
	Damages	0.66	8
	Improper subcontractor/contractor selection	0.65	9
	Non conformance to specification/quality	0.65	9
	Lack of coordination/planning	0.64	11
	Failure	0.60	12
	Improper sequence of work	0.60	12
	Omission	0.59	14
	Improper work protection	0.56	15

Causes of rework

Table 3 displays the causes of rework. The causes of rework were grouped into client related, design related and subcontractor related causes. Respondents rated the causes in a likert scale of 1= nil, 2 = low, 3=moderate, 4=high and 5= very high. The most rank causes are poor communication with design consultant(mean =3.90), Use of poor quality materials(mean =3.83), poor workmanship(mean =3.79), lack of experience and knowledge of design and construction process(mean =3.75), incomplete design as at time of design(mean =3.73), damages and inadequate managerial/supervisory skills(mean =3.65), defects and poor coordination between the design consultant (mean =3.60).The least causes of reworks are lack of manpower to complete required task(mean =3.08), staff turnover/re-allocation to other project(mean =2.97), lack of client involvement in the project(mean =2.87).

TABLE III. CAUSES OF REWORK

S/N	Causes of rework		
		MIS score	***Rank***
	Poor communication with design consultant	0.78	1
	Use of poor quality materials	0.77	2
	Poor workmanship	0.76	3
	Lack of experience and knowledge of design and construction process	0.75	4
	Incomplete design as at time of design	0.74	5
	Damages	0.73	6
	Inadequate managerial/supervisory skills	0.73	6
	Defects	0.72	8
	Poor coordination between the design consultant	0.72	8
	Insufficient time to prepare contract documentation	0.71	10
	Incidence of conflicting opinion between design team	0.71	10
	Inadequate briefing	0.70	12
	Inadequate client brief to prepare detailed contract documentation	0.69	13
	Poor planning of workload	0.69	13
	Ineffective use of management practice	0.68	15
	Inadequacies in contract documentation	0.67	16
	Lack of funding allocated for site investigation	0.66	17
	Constructability associated concerns	0.66	17
	Ineffective use of information technologies	0.65	19
	Omission of some activity or task	0.64	20
	Time boxing /fixed time for the task	0.63	21
	Poor site condition	0.62	22
	Failure to provide protection for construction work	0.62	22
	Lack of manpower to complete required task	0.61	24
	Staff turnover/re-allocation to other project	0.59	25
	Lack of client involvement	0.57	26

Effect of rework on initial contract sum

Predicting rework cost from initial contract sum using linear regression analysis yields the following result presented in Table 4. The multiple correlation coefficient, R (= 0.987), implies strong relationship existing between the set of predictor and the predicted variable. The level of significance calculated is 0.029 at t-test value of -3.037.It shows the variables are significant at 5% level of significance.R^2 value is 0.974 and the spearman rank correlation(r) is 0.893. It can be deduced that there is a strong positive correlation between the variables. Thus an increase in a unit of one of the initial contract sum led to an increase in the rework cost. The alternate hypothesis (H_1) is therefore accepted.

Hence the predicting equation is
RC = -7307383.765 + 0.031ICS

Where: RC = Rework cost
ICS = Initial contract sum

TABLE IV. PREDICTIVE MODEL OF THE EFFECT OF REWORK COST ON INITIAL CONTRACT SUM

Initial contract sum	R	R2	Unstandardized coefficient	standardized coefficient	T	Sig.	Rmk	r	Dec.
			B	Beta					
0.031	.98	.97	-7307383.765	0.987	-3.03	.02	Sig	.893	H_1 accptd

Effect of rework on final contract sum

Regression analysis is used to predict the significant relationship between rework cost and final contract sum. From table 5, there is no significant relation between rework cost and final contract at 95% level of significant hence the null hypothesis (H0) is accepted. Although spearman correlation coefficient(r) value of 0.75 shows that there is a positive correlation between the two variables. R^2 calculated also show a joint influence of 38% between the dependent and independent variable. The predicted model equation is
RC = 2517144.705 + 0.031FCS

Where: RC = Rework cost
FCS = Final contract sum

TABLE V. PREDICTIVE MODEL OF THE EFFECT OF REWORK COST ON FINAL CONTRACT SUM

Final contract sum	R	R2	Unstandardized coefficient	standardized coefficient	T	Sig.	Rmk	r	Dec.
			B	Beta					
0.031	.62	.38	2517144.705	0.622	-.208	.85	NS	.75	H_1 accptd

Effect of rework on initial contract period

Table 6 displays the effect of rework cost on initial contract period. Linear regression was used to show this relationship. The beta coefficient is 47%, it indicates the change in the dependent variable that will be produced by a positive increment of the standard deviation in the independent variable. The t statistic test is 1.19 with a p-value of 0.287 as shown in the table 6.However this is not significance at 95% level of significant, hence the null hypothesis(H_O) which state rework cost cannot be predicted from initial contract period is accepted. The spearman correlation coefficient(r= 0.582) shows a moderate correlation between the variables.

Therefore the predicted equation is:
RC = -2221416.577 + 832962.34ICP

Where: RC = Rework cost
ICP = Initial contract period

TABLE VI. PREDICTIVE MODEL OF THE EFFECT OF REWORK COST ON INITIAL CONTRACT PERIOD

Initial contract period	R	R2	Unstandardized coefficient	standardized coefficient	T	Sig.	Rmk	r
			B	Beta				
832962.34	.47	.221	-2221416.577	0.47	1.19	.287	NS	.582

Effect of rework on final contract period

Table 7 displays the effect of rework cost on final contract period. Linear regression was used to show this relationship. The beta coefficient is 0%,it indicates the change in the dependent variable that will be produced by a positive increment of the standard deviation in the independent variable. The t statistic test is 0.456 with a p-value of 0.672 as shown in the table 7.However this is not significance at 95% level of significant, hence the null hypothesis(H_O) which state rework cost cannot be predicted from final contract period is accepted. The spearman correlation coefficient(r= 0.265) shows a low correlation between the variables. Therefore the predicted equation is:

RC = 3644158.88 + 233.645FCP

Where: RC = Rework cost
FCP = Final contract period

TABLE VII. PREDICTIVE MODEL OF THE EFFECT OF REWORK COST ON FINAL CONTRACT PERIOD

Final contract period	R	R2	Unstandardized coefficient	standardized coefficient	T	Sig.	Rmk	r
			B	Beta				
233.645	.00	.00	3644158.88	0.00	.456	.672	NS	.265

Discussion of findings

This study identifies changes and defect as the most significant sources of rework on construction project. In the same light, [22] revealed that change is the most common source of rework in construction projects in Australia. Similarly, a study by [28] showed agreement with aforementioned studies by stating that most incident of rework on selected construction projects in South Korea were attributed to error and/or to a change, although it was not considered as an important source in building projects in the research findings of [24, 29]. Reference [30] highlighted quality failure and defects is the most significant source of rework. The inappropriate differentiation between terms such as quality failures, defects, and errors can lead to inaccurate and incomplete measurements for rework and possibly inappropriate strategies for reducing its occurrence. The various writers have viewed rework as almost a right in itself i.e. that rework is inevitable and acceptable.

This study also considers the poor communication among consultants as the significant cause of rework on construction projects. However, other research work by [26] showed that a combination of poor communication and lack of coordination and integration between participants during the design process is responsible for the increase in rework on construction projects in South Korea. While incomplete design as at the time of design is said to have less influence on causing rework in building projects in Nigeria in the current study, it ranked as a significant factor in the studies by [26, 31, 32]. Reference [31, 32] reported that rework cost of some major contractors in Australia, equal 5% of contract value were attributed to poor documentation produced by design consultants.

CONCLUSIONS

In conclusion, this research centered on causes and effects of rework on building projects hence the causes of rework identified from this study are poor communication with design consultant, use of poor quality materials, poor workmanship and lack of experience and knowledge of design and construction process and the sources of rework as identified from this study are changes, defects, quality deviation, poor workmanship and inadequate supervisory/managerial skills.

The analysed effects of rework on project performance in term of time and cost are identified to show that rework cost can be calculated if the final cost and duration are evaluated. Therefore the relationship between rework cost and final contract cost and duration gives this predictive model equation:

RC = 2517144.705 + 0.031FCS

RC = 3644158.88 + 233.645FCP

It is therefore recommended that the client, consultant and contractor should have adequate understanding of the design at the early stage of the project in order to reduce variation or modification of design or change order which led to rework. There should be adequate communication between the consultant and the contractor. The contractor should also enhance to the specification of the project to ensure quality performance of the project.

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