Effect of Cost of Scaffolding on Cost of Preliminaries in Multi-Storey Building Projects in Abuja, Nigeria

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Abstract

This paper investigated the relationship between cost of scaffolding and total cost of preliminaries for fifty construction projects in Abuja, Nigeria. Data used for the study were obtained using pro forma method of data collection for both cost of scaffolding and preliminaries for all the fifty (50) multi-storey building projects studied. The use of both descriptive and inferential statistics was adopted to analyze the collected data. Percentage was used for the descriptive analysis while hierarchical multiple regression analysis was used for the inferential analysis and development of predictive models. It was discovered from the analysis that cost of scaffolding carries a significant proportion from total cost of preliminaries and a positive, strong and significant relationship exists between the cost of scaffolding and the total cost of preliminaries in multi-storey building projects. The respective strong value of coefficients of correlation and determination observed ranges from 76% – 80% and 59% – 62%. The degree of association between the cost of scaffolding and total cost of preliminaries and that between the cost of scaffolding and total cost of construction were also respectively found to be strong. The coefficient of correlation ranges from 75% to 80%. All the three predictive regression models formulated were discovered to be suitable for predicting the cost of scaffolding with the use of the total cost of preliminaries and total construction cost at 95% confidence limit. It was suggested that consultants and contractors should ensure that cost of scaffolding is measured in detail at the pre-contract stage and that larger project samples should be used in further studies to formulate better predictive models for cost of scaffolding.

Keywords: *Multi-Storey Building, Predictive Model, Preliminaries, Scaffolding, Temporary Work.*

INTRODUCTION

Background to the Study: The construction of multi-storey buildings involves the fabrication and erection of temporary structures and other preliminary works.

According to Ratay (2014) temporary structures are structures erected to aid in the construction of a permanent project. Temporary structures are used to facilitate the construction of buildings, bridges, tunnels, and other above – and below ground facilities by providing access, support, and protection for the facility under construction, as well as assuring the safety of workers and the public (British Standard, 2008). Temporary structures are either dismantled and removed when the permanent works become self-supporting or completed, or they are incorporated into the finished work. Temporary structures are also used in inspection, repair, and maintenance work. Temporary structures include cofferdams, earth-retaining structures, Tunneling supports, underpinning, diaphragm/slurry walls, roadway decking, construction ramps, runways, & platforms, scaffolding/scaffolds, shoring, falsework, concrete formwork and bracing & guying among others.

Scaffolds are temporary structures built to facilitate the work of labourers, mostly at higher-than ground- level elevations and they are an integral part of any high-rise construction operation, be it in the field of residential or industrial construction (Kumar et al, 2013). While the scaffolding process is often considered to be of lesser importance within the overall project, it accounts for a significant amount of project cost and labour-hours. Understanding scaffolding construction requirements necessitates extensive knowledge of the geometrical features and space accessibility of structures on industrial projects, in addition to involvement of different trades that share the scaffolds. Contributing factors involved in scaffold estimates include the list of trades that work in a construction area, trade working hours, volume of work, elevation at which the scaffold is to be constructed, time of the year of construction, skill level of the workers, ease and type of material availability, etc. However, not all factors share the same level of importance in the estimating process.

According to Olatunji (2014) the construction industry has had considerable criticisms on inefficiencies in the quality and outcomes of professional services in project delivery. These criticisms have spanned design, estimating, procurement and construction, whilst a range of manifestations of inefficiencies have been reported in forms of errors, conflicts, omissions, mistakes and descriptive ambiguities. The use of lump sum or percentage from total cost of construction to estimate cost of scaffolding also results to inefficiencies in the quality and outcomes of professional services in project delivery because this estimate is usually inaccurate.

Risk expected from the above inaccuracies and inefficiencies are mitigated in the course of reliable prediction. A probabilistic model is proposed to predict the risk effects on time and cost of construction projects (Hammad et al, 2008). Project managers and consultants can use the model in estimating project cost and duration based on historic data. Statistical regression models and sample tests are developed using real data from projects to achieve this.

In the light of this, Lawther and Edwards (2000) reported that accurate cost modeling is fundamental to the efficiency of the construction industry in general, and the stakeholders within the industry in particular. Cost models are technical aids which enable management decisions to be made in the context of building design (Skitmore and Marston, 1999). The primary function of cost models in this context is to provide reliable cost forecasts (Elhag and Boussabaine, 1998), either for the client or the contractor (Ashworth, 1999).

According to Ogunsemi and Yagboro (2001), the nature of preliminary items of a bill of quantities are such that it covers financial matters which relate to the contract as a whole and not confined to any particular work section. They consist of those tangible things that are essential and indeed a pre-requisite towards a successful project construction which a contract needs to put in place. Cartlidge (2009), opined that the preliminaries section of the bills of quantities contains items that are of a general nature that may affect the contractor's tender the SMM7, splits preliminaries items into section that deals with employers requirements and general cost items. The cost items are further split into fixed charges. Fixed charges, the cost of which is considered to be independent of duration; charges that are not proportional either to the quantity of the work or its duration. Time-related charges, the cost of which is dependent on duration. Ayorinde (1990) cited in Ogunsemi and Jagboro (2001), observed that the preliminaries section of the bill of quantities also gives the estimator a fair chance to price all works connected with construction of the project that cannot be measured according to the standard method of measurement. Ogunsemi and Jagboro (2001), also asserted that although the preliminaries sector of bills of quantities tends to contain many items, several of them are difficulty to quantify and price and for this reason, it is usually only the major items such as accommodation, staffing and mechanical plant that are priced.

The relationship between the cost of scaffolding and cost of preliminaries/construction has not been well studied by researchers. The main emphasis had been to stress the importance of scaffolding from the cost of construction and to make known the consequences of inappropriate estimation of cost of scaffolding, as revealed in this background. In order to fill this research gap, this study was set out to model the cost of scaffolding in multi-storey building projects to address the problem of inaccuracies in the estimate of cost of scaffolding in construction projects.

Statement of Research Problem

Despite the fact that formwork and scaffolding are indispensable in the construction industry because of the myriad ways in which they are used as mentioned above, formwork are measured when estimating as a work item, while scaffolding is not but given as a lump sum allocated in preliminaries. This inadequate means of calculating cost of scaffolding often leads to cost overrun because scaffolding cost carries a significant proportion of cost of preliminaries in construction projects. This study therefore used the idea of cost modeling based on historic data to solve the problem of inaccuracies in the estimation of cost of scaffolding for enhanced project delivery based on the studies of Shittu et al (2008), Shittu and Izam (2011), Aiyetan et al, (2012) and Shittu et al (2013) where historic data were used to formulate cost models for forecasting.

Aim

To determine the effect of scaffolding on the total cost of preliminaries in multi-storey building projects with a view to formulating a model for predicting cost of scaffolding which is one of the major items of temporary works in multi-storey construction projects.

Objectives

i. To determine the proportion of the cost of scaffolding from the total cost of preliminaries in multi-storey building projects.
ii. To determine the proportion of the cost of scaffolding from the total cost of construction in multi-storey building projects.
iii. To determine the relationship between the cost of scaffolding and the total cost of preliminaries/construction cost in multi-storey building projects.

Statement of Hypotheses

$H_0 1$: There is no significant relationship between cost of scaffolding and the total cost of temporary works in multi-storey building projects.

$H_0 2$: There is no significant relationship between cost of scaffolding and the total construction cost in multi-storey building projects.

Scope of the Study

The study covered Abuja metropolis where fifty storey building projects were examined from information gathered from selected construction firms from the six Area Councils in Abuja registered with the Federation of Construction Industry (FOCI). The selected projects are among projects executed between 2011 and 2013; with project cost ranging from =N= 45,000,000.00 - N1,000,000,000; and storey height between 2 – 5 storeys.

Limitation

The study has developed cost model for the prediction of the value of scaffolding in relation to preliminaries and total contract sum. The derived model did not show the other variables that make up the preliminaries section of the bill of quantities nor the constituents of total contract sum. Ogunsemi and Jagboro (2001), have opined that preliminaries could be modeled by determining the factors affecting its value which may be considered to could include contract sum, size of building, complexity of the structure, location, distance from capital city, price index, total floor area, the number of floors perimeter length of walls, external finishing, number of lifts, size of site, bank rates, construction type, condition of contract, contract period, temporary roads, tower cranes among others.

METHODOLOGY AND DATA COLLECTION

This research involved the use of quantitative approach with the use of numeric data. The research population comprises of the number of construction firms registered with FOCI which was 84. The number of construction firms domicile in Abuja out of this total was 50 and this formed the sample size considered for the study. The whole 50 construction firms were selected so that the sample will be large enough for the method of analysis adopted in the study. Data were collected from the secondary source, which is archival data from the projects executed by selected construction firms which met the project characteristics already mentioned above. In the light of this, a project which best meets the project characteristics for the study was selected from each construction firm. The use of data collection profoma was employed to gather information on the actual cost incurred on scaffolding, preliminaries and the total cost of construction from the contract documents of the selected construction firms. The use of tables and bar charts were employed to present data collected on the cost incurred on scaffolding and the total cost of construction from the selected projects.

Analysis of data was carried out using both descriptive and inferential statistical techniques. For the descriptive statistics, the use of percentage was employed to determine proportion of the cost of scaffolding from the total cost of temporary works and total cost of construction respectively. For the inferential statistics, the use hierarchical multiple regression analysis was employed to determine the statistical relationship existing between the cost resulting from scaffolding and the total cost of construction and to also develop a model for predicting the cost of scaffolding, with the aid of the computer software package called the Statistical Package for Social Sciences, Version 13.0 (SPSS 13.0). The use of this method was because more than one variable (two variables) were used to predict cost of scaffolding and hierarchical multiple regression makes it possible for variables to be entered in steps (or blocks), with each independent variable being assessed in terms of what it adds to the prediction of the dependent variable after the previous variables have been controlled for, as reported by Pallant (2013).

In addition, Shittu et al (2008) studied the cost of mechanical and electrical services in residential building projects by using simple and multiple regression analyses to develop models

for forecasting cost of serices with the use of selected design variables in bungalow and multi – storey building projects. This study was based on the procedure developed by Swaffield and Pasquire (1999). Ogunsemi and Jagboro (2001), undertook a study on modeling of the cost of preliminaries for residential buildings in Nigeria. In the same vein, Shittu and Izam (2011) and Shittu et al (2013) used multiple regression analysis to develop predictive models for forecasting cost of services in residential & commercial buildings in Abuja & Niger State and cost of services in institutional buildings in Lagos State respectively using selected building form descriptors.
All the above mentioned studies were carried out to solve the problem of ineffective cost control which results to cost overrun and delay in project delivery. However Ferry and Brandon (1991), Jagboro (1995) and Morenikeji (2006) defined a model as an abstraction from reality and can be expressed in the form of hardware like the Architect's model of a dream house or a mathematical equation or a theory, which helps to simplify complex situation. In the light of the above, this research adopted the approach used in the previous studies discussed to develop predictive models for forecasting the cost of scaffolding in multi-storey building projects.

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

Data Presentation

The data collected for this study are presented below in Table 1.

Table 1: Research Data Showing Costs of Projects, Preliminaries and Scaffolding

PROJECT NO	CONTRACT SUM (=N=)	COST OF PRELIMINARIES (=N=)	COST OF SCAFFOLD (=N=)
1	618,500,000.00	84,370,000.00	7,300,000.00
2	609,841,275.00	87,500,000.00	8,500,000.00
3	60,496,000.75	1,000,000.00	200,000.00
4	369,986,330.38	16,265,859.67	3,637,464.01
5	858,543,673.95	39,881,776.00	6,850,000.00
6	548,318,405.94	41,500,000.00	3,403,000.00
7	54,406,035.69	1,000,000.00	230,000.00
8	956,550,020.06	63,000,001.33	4,284,000.09
9	229,984,516.16	31,584,602.52	1,700,000.00
10	175,340,025.00	3,000,000.00	108,000.00
11	625,449,789.30	67,270,000.00	3,000,000.00
12	542,788,627.50	65,130,000.00	2,500,000.00
13	743,292,847.86	42,548,582.34	7,000,000.00
14	88,713,976.05	8,871,397.61	1,437,166.41
15	195,104,927.35	9,755,246.37	1,580,349.91
16	47,967,226.20	4,796,722.62	777,069.06
17	222,946,756.25	8,917,870.25	1,444,694.98
18	99,970,000.00	5,998,200.00	971,708.40
19	255,370,938.38	9,500,000.00	2,000,000.00
20	207,531,508.45	9,500,000.00	1,800,000.00
21	240,000,000.00	9,600,000.00	2,000,000.00

Table 1 contd.

22	45,740,781.86	4,482,590.62	941,345.29
23	68,598,561.54	8,231,827.38	1,481,728.92
24	152,780,781.00	15,278,078.10	2,475,048.65
25	112,334,428.57	10,154,795.06	1,645,076.80
26	196,054,658.24	19,605,465.82	3,176,085.46
27	88,298,710.12	5,297,922.61	858,263.46
28	49,652,327.25	2,482,616.36	402,183.85
29	684,575,485.65	75,303,303.42	2,861,525.53
30	179,457,288.90	15,253,869.55	1,921,987.56
31	198,899,132.52	17,900,921.92	2,386,789.59
32	129,487,284.52	12,948,728.45	1,592,693.60
33	45,296,926.00	7,500,000.00	1,140,000.00
34	195,148,927.35	23,417,871.28	2,888,204.12
35	470,026,939.95	13,501,346.99	1,786,102.37
36	97,004,373.38	1,500,000.00	850,000.00
37	58,880,172.50	1,250,000.00	677,603.50
38	47,292,388.63	1,164,619.43	482,382.36
39	49,095,180.98	1,823,541.50	736,427.71
40	106,499,668.73	3,714,280.00	2,002,193.77
41	173,331,117.86	8,666,555.89	3,466,622.36
42	97,419,930.20	2,702,355.89	828,069.41
43	73,775,370.00	2,094,020.00	922,192.13
44	79,046,485.29	1,748,719.32	988,081.07
45	47,743,828.44	8,439,000.00	80,000.00
46	430,769,922.20	52,915,939.33	1,550,000.00
47	84,175,250.17	2,155,678.64	779,427.44
48	604,448,209.06	79,350,000.00	7,000,000.00
49	413,508,744.83	48,584,648.16	2,000,000.00
50	310,461,859.65	32,000,000.00	1,200,316.62

Source: Authors Field Work showing the value of contract sums, costs of preliminaries and costs of scaffolding for fifty (50) selected multi – storey building projects collected from the professionals visited for data collection in Abuja.

RESULTS AND DISCUSSIONS

Results of Descriptive Analysis

The results of the descriptive analysis of data were presented using line and bar graphs and discussed below.

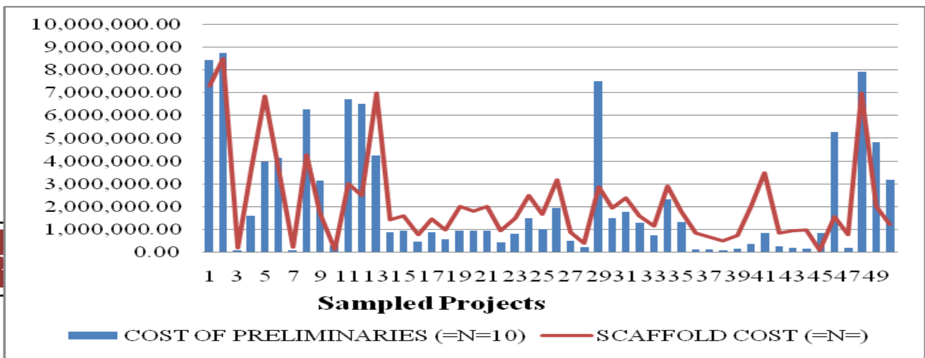


Figure 1 Cost of Scaffolding in Relation to Cost of Preliminaries

In Figure 1, a comparative analysis was made between cost of preliminaries and cost of scaffolding. The cost outlay showed a similar trend. While Figure 2 shows the percentage proportion of the cost of scaffolding from the total cost of preliminaries for the thirty (30) selected multi – storey building projects. It was observed that there is a wide variation in the percentages shown among the selected projects. The proportion as observed from the graph ranges between 3.6% and 30.21%, giving an average of about 20%. This implies that the cost of scaffolding constitutes a significant cost item from the total cost of preliminaries since the average percentage of cost of scaffolding from the total cost of preliminaries is about 20%, which is a significant proportion considering the wide range of items which constitute preliminaries. This agrees with the finding of Kumar et al (2013) that in spite of the fact that the scaffolding process is often considered being of lesser importance within the overall project, it accounts for a significant amount of project cost and labour-hours.

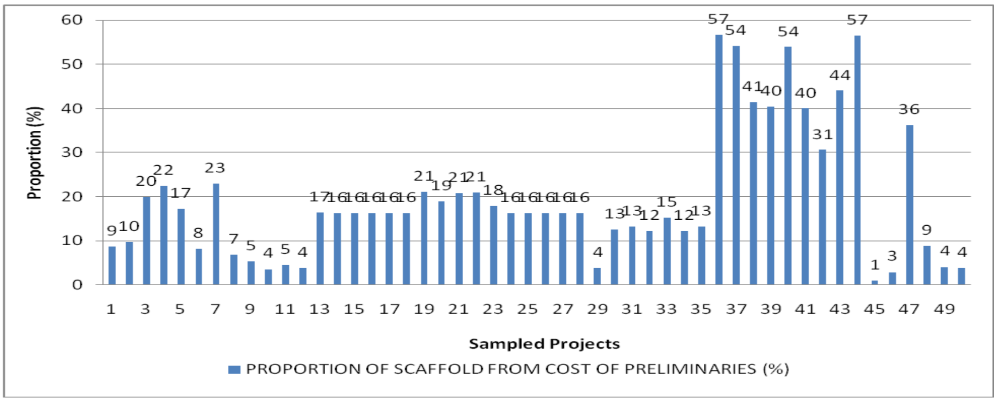


Figure 2: Percentage Cost of Scaffolding in Relation to Total Cost of Preliminaries

Figure 2 shows the percentage proportion of the cost of scaffolding from the total cost of preliminaries for the fifty (50) selected multi – storey building projects. It was observed that there is a wide variation in the percentages shown among the selected projects. The proportion as observed from the graph ranges between 1% and 57%. This implies that the cost of scaffolding constitutes a significant cost item from the total cost of preliminaries.

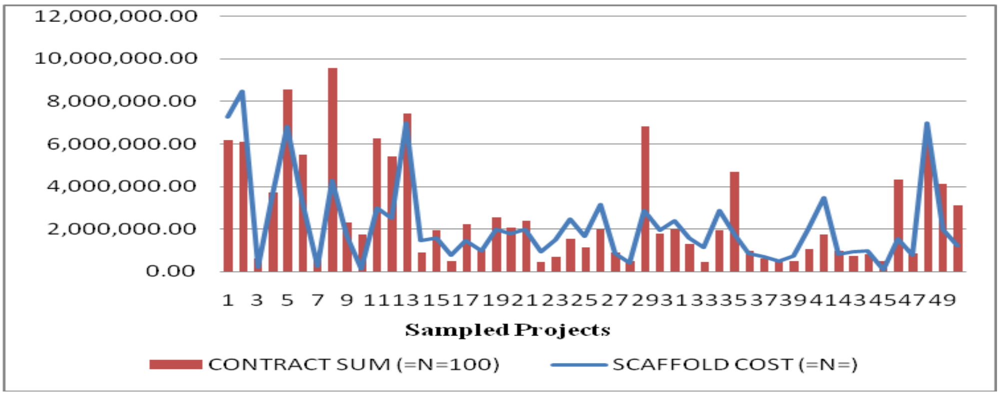


Figure 3: Cost of Scaffolding in Relation to Total Contract Sums

Figure 3, indicates that the cost of scaffolding in proportion to the contract sum is less than 10%.This is shown clearly in Figure 4. The percentage proportion of the cost of scaffolding from the total cost of construction for the thirty (50) selected multi – storey building projects was shown in Figure 4. It was observed that there is a wide variation in the percentages observed among the selected projects. The percentages as can be seen from the graph ranges from 0.1% to 2.5%. This implies that the cost of scaffolding constitutes a significant preliminary cost item from the total cost of preliminaries because in most projects the percentage proportion usually allocated for cost of preliminaries ranges from 5% to 10%. Therefore out of this range of 5% – 10% for several preliminary items in a project, 2.5% which goes to scaffolding cost is a significant cost item.

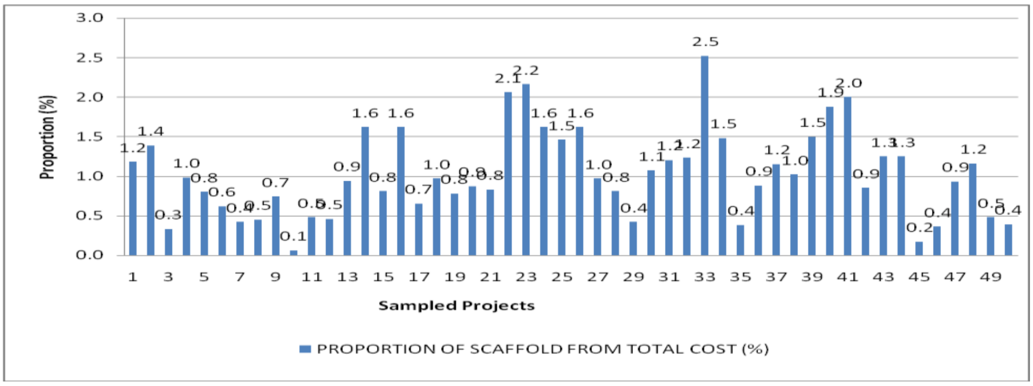
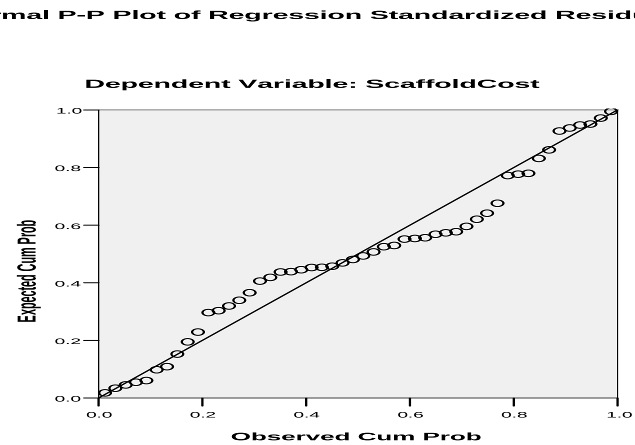


Figure 4: Percentage Cost of Scaffolding in Relation to Total Contract Sums

Results of Inferential Analysis

Hierarchical multiple regression analysis was used to assess the ability of total construction cost as a control measures to predict cost of scaffolding after controlling for the influence of cost of preliminaries. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearaity and homoscedasticity. The preliminary analyses revealed that there was no violation of the assumptions of normality, linearity, multicollinearaity and homoscedasticity because the tolerance value was greater than 0.10, variance inflation factor (VIF) value less than 10, Normal P-P Plot points lie in a reasonably straight diagonal line from bottom left to top right and the Scatterplot standardized residuals roughly rectangularly distributed. The maximum Cook's Distance in the analysis is 0.719 which is less than 1 indicating the absence of any undue influence on the results of for the whole model. The P-P plot and



Scatterplot mentioned above are presented as Figures 5 and 6 respectively:

Figure 5: Normal P-P Plot of Observed & Expected Cumulative Probability Cost of Scaffolding

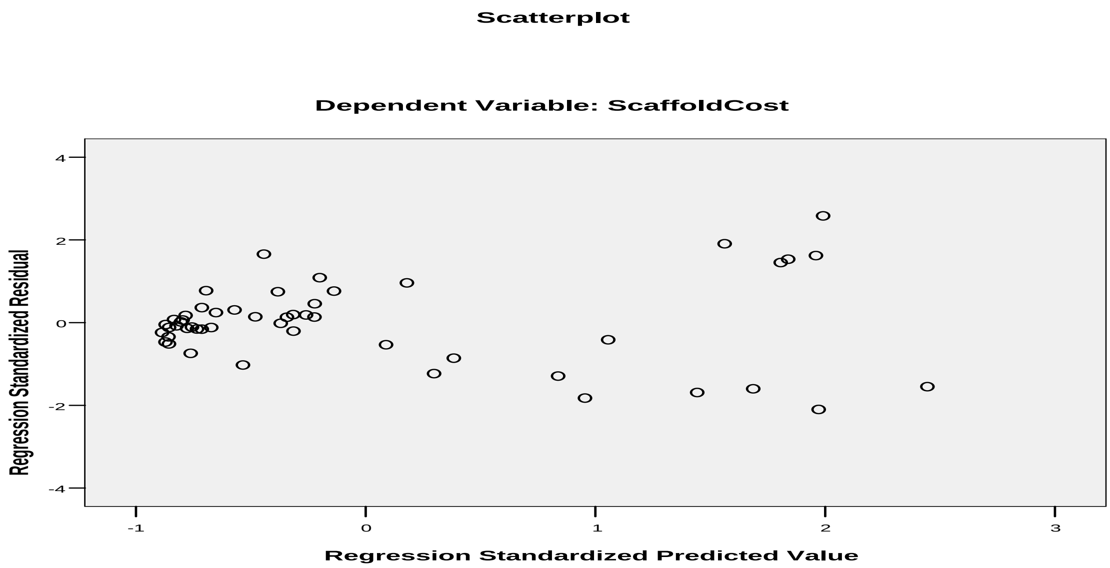


Figure 6: Scatter Plot of Regressed Standardized Predicted & Residual Values of Cost of Scaffolding

Cost of preliminaries was entered at Step 1, explaining 76.8% of the variance in cost of scaffolding. After entry of total construction cost at Step 2 the cumulative variance explained by the model as whole increased to 80.9%, $F (2, 47) = 44.397$, $p < 0.001$. In the final model, both cost of preliminaries (beta = 0.384; $p = 0.05$) and total construction cost (beta = 0.490; $p < 0.05$) were statistically significant to cost of scaffolding with strong and positive correlation coefficient of 76.8% and 78.9% respectively. This therefore implies that both cost of preliminaries and total construction cost are significantly related with cost of scaffolding at 95% confidence limit. The null hypothesis was therefore rejected. The model which gives the better predictive model is therefore Model 2. Table 3 gives a summary of these results. This result is intandem with the study of Babalola and Jagboro (2001) as cited in Ogunsemi and Jagboro (2001), established a high predictive model between the relationship of the cost of preliminaries and the total cost of construction. This result also agrees with the finding of Kumar et al (2013).

Table 2: Results of Hierarchical Regression between Cost of Preliminaries/Total Construction Cost & Cost of Scaffolding

Model No.	Variables		Observations							Inferences	
	X	Y	Regression Equation	R/R^2 (%)	Std. Error	VIF	Tolerance	Cooke's Dist	Sig.	Strength of Relationship	Remark
1	Cost of Preliminaries	Cost of Scaffolding	Y = 876980.9 + 0.061x	77/59	0.007	1.000	1.000	0.719	0.000	Strong	SS
2	Cost of Preliminaries	Cost of Scaffolding	Y = 544590.6 + 0.027x	77/59	0.013	3.789	0.264	0.719	0.043	Strong	SS
	Total Construction Cost	Cost of Scaffolding	Y = 544590.6 + 0.004x	79/62	0.001	1.566	0.639	0.719	0.005	Strong	SS

Key: SS = Statistically Significant

PREDICTIVE MODEL DERIVED

From the regression analysis carried out in this study, three predictive models have been formulated and these are summarized in Table 3.

Table 3: Predictive Regression Models

Model Number	Predictive Regression Model/Equation Formulated
1	Cost of Scaffolding = 544590.6 + 0.027Total Cost of Preliminaries
2	Cost of Scaffolding = 544590.6 + 0.004Total Construction Cost
3	Cost of Scaffolding = 544590.6 + 0.027Total Cost of Preliminaries + 0.004TotalConstruction Cost

From Table 3, it was observed that all the three models are good predictors of cost of scaffolding. The first model shows the use of total cost of preliminaries to predict cost of scaffolding; the second model shows the use of total construction cost to predict cost of scaffolding while the third model shows the use of a combination of both cost of preliminaries and total construction cost to predict cost of scaffolding.

CONCLUSIONS AND RECOMMENDATIONS

A positive, strong and significant relationship exists between the cost of scaffolding and the total cost of preliminaries; and the total cost of construction in multi-storey building projects with strong values of coefficients of correlation. In fact, the degree of association of the relationship between the cost of scaffolding and total cost of preliminaries and that between the cost of scaffolding and total cost of construction respectively were discovered to be strong with strong coefficient of correlation.

It can therefore be concluded that cost of scaffolding can be predicted using the total cost of preliminaries and the total cost of construction in multi-storey building projects; and the cost of scaffolding carries a significant proportion from the total cost of preliminaries and the total cost of construction out of all the preliminary items in multi-storey building projects. Hence, the cost of scaffolding should always be put into consideration when a construction estimate is being prepared at pre-contract stage of a project. Consultants and contractors should therefore ensure that the cost of scaffolding is measured in detail at the pre-contract stage and a professional estimator oversees and co-ordinates the whole construction process that make up the total values of preliminaries and that of total cost.

Owing to the limitations of the study, larger variables should be used in further studies to obtain a better predictive model for cost of scaffolding in multi-storey building projects, this observation not withstanding, provides a background for further research in to the subject matter.

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