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Development of a Predictive Model for the Quantification of Roof Covering in Tetfund Projects in Universities in Anambra State

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***Abstract* - The quantification of roof covering in the early stages of building project estimation remains a critical challenge, particularly in projects funded by Nigeria's Tertiary Education Trust Fund (TETFund). Inaccurate estimations often lead to budget overruns and project delays, undermining the efficiency of fixed-sum contracts common to TETFund projects. This study developed a regression-based predictive model for quantifying roof-covering in TETFund projects across universities in Anambra State. Data was collected from twenty-five TETFund buildings at Nnamdi Azikiwe University, Awka, and Chukwuemeka Odumegwu Ojukwu University through physical measurements and secondary sources. Key variables, including gross floor area, external blockwork centerline girth, and roof pitch, were analyzed using correlation and regression techniques. The developed model enables reliable roof covering area estimation, mitigating risks associated with cost misallocation and enhancing project efficiency. The findings provide a robust framework for improving estimation practices, ensuring cost alignment, and bolstering the operational effectiveness of TETFund projects.**

Keywords: Regression model, quantification, predictive, roof covering, TETfund projects.

I. INTRODUCTION

The quantification of roof covering is often a major challenge during the early stages of building project estimation. One of the primary reasons for this difficulty is the limited time allocated for the measurement of roofs, which can result in errors and inaccurate estimates [12]. This issue is particularly pronounced at the sketch design stage, where quantity surveyors need to determine budgetary requirements to ensure that the project cost aligns with the client's approved budget.

Unfortunately, it has been observed that a significant number of building projects are completed above the client's budget, and this problem is especially prevalent in Tertiary Education Trust Fund (TETFund) building projects due to funding and budget allocation issues [9]. TETFund building projects typically operate on fixed-sum contracts and demand early payment of the total proposed building cost, even when working drawings are insufficient or incomplete [9]. Inaccurate estimations in such situations only exacerbate the problem, leading to project delays and misallocating funds [7].

Although studies have been carried out on the TETFund project delivery performance [1], [2], none have assessed the various models that TETFund can apply in the quantification of any part of their projects. It is also important to note that while studies have been carried out on the development of regression models for various purposes and contexts, there seems to be a dearth of studies on any available model for cost prediction and quantification of TETFund projects. [3] Applied the principal component regression model to study the project cost prediction model for public building projects in Nigeria. In like manner, [13] made efforts to establish regression models for Predicting Quantities and Estimates of Steel Reinforcements in Concrete Beams of Frame Buildings. For residential buildings exclusively, the model that fits this study the best was created by [4] for long-span aluminum roofing sheets with a pitch between 25 and 39 degrees. Consequently, as the amount depends on the pitch, the estimation of the roof covering amounts for any proposed residential flat must meet the model's requirements. Lekan’s study used only one independent variable which is; “the area of the roof on plan”. Therefore, this study developed a predictive model for quantifying the roof covering area in TETFund projects in universities in Anambra State, Nigeria.

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II. LITERATURE REVIEW

2.1 Quantification of the area of roof covering

A building's roof covering is the material that covers the roof deck. The roofing system recommended to adequately waterproof the structure determines the sort of covering that is utilized [12]. Since the 1950s, attempts have been undertaken to create quantity models to estimate building costs and comprehend the cause-and-effect relationship between design elements and building expenses. According to [12], cost modeling is a symbolic representation of a system and its contents that include the variables influencing the cost.

Currently, there are limited studies related to models for the quantification of the area of roof coverings. A few studies were carried out by [4] and [12]. These studies were based on developing a model for the quantification of roof coverings for residential buildings. No preference has been given to public buildings in general, and TETFund buildings specifically. Studies from [7] and [5] have also established regression models for different purposes including Energy Consumption, Road Construction, and Electrical Cables for Residential Buildings in Nigeria respectively.

2.2 TETFund and Project Facilitation in Nigerian Universities

The Nigerian government instituted TETfund as an intervention mechanism to improve the quality and standard of education, especially at the tertiary level, and to lessen the financial issues in the university educational system. It was primarily created to guarantee sufficient funding for the industry, especially at the tertiary level, which is necessary to provide people with high-quality educational facilities and structures to help them solve the many issues that the university education system faces [14]. It was established by an Act of law. The Act that established the Fund also provided criteria for allocating education tax accruals to colleges, universities, and polytechnics in the following ratios: 2:1:1 [10]. The TETFund has been in charge of developing, supplying, and delivering this infrastructure to Nigerian public tertiary institutions since the Act in 2011. The mandate of the fund as provided in section 7 (1) (a) to (e) of the TETFund Act, 2011 is to administer and disburse the amount in the fund to Federal and State tertiary educational institutions, specifically for the provision and maintenance of critical educational infrastructure.

[8] Assert that TETFund assists in the facilitation of projects. To ensure that projects are carried out effectively and contribute to the administration of the university system in which they are located, the TETFund is expected to monitor project execution, as the authors assert that both project facilitation and the funding function of the TETFund should be carried out with a zero-exclusion ratio. Given the significance of facilities in the nation's higher education administration, both the number and caliber of projects must be able to support the management of the educational system. Facilities made available in the benefiting institutions should have an influence that both professors and students can sense, instead of just stating that facilities have been made available, and the agency should make sure that they are sufficiently high-quality [8].

III. RESEARCH METHODOLOGY

The research methodology adopted a quantitative approach focused on developing a predictive model for the quantification of roof covering to achieve the research aim. The study employed purposive sampling to collect data from twenty five (25) TETFund buildings at Nnamdi Azikiwe University, Awka (NAU) and Chukwuemeka Odumegwu Ojukwu University (COOU). Primary data collection involved physical measurements of floor area, external blockwork centerline girth, roof pitch, and actual roof covering area using calibrated measuring tools, while secondary data included TETFund project records and as-built drawings. Data analysis followed a systematic approach, beginning with preliminary analysis for data cleaning and descriptive statistics, followed by correlation analysis to establish relationships between variables, and culminating in regression analysis for model development. The statistical analysis employs multiple regression techniques to develop the predictive model, with validation through R-squared analysis, and cross-validation methods. The research instruments include measuring tapes, and statistical software for analysis, with all procedures documented systematically to ensure reproducibility.

Table 3.1: Sampled data series of Area of Roof Coverage, Upper/Ground floor area, External block wall centerline girth, and Pitch at (NAU and COOU)

Sample No.	Location	Area of Roof Coverage (m^2)	Gross Floor Area (m^2)	External Blockwall centreline Girth (m)	Pitch (m)
1	NAU	1,054	743	164	3.30
2	NAU	952	884	197	2.00
3	NAU	823	502	126	5.62
4	NAU	833	553	122	4.18

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5	NAU	3,356	1,969	401	3.30
6	NAU	2,137	1,317	234	6.72
7	NAU	631	487	109	4.40
8	NAU	390	267	79	3.60
9	NAU	1,335	945	173	5.16
10	NAU	865	459	105	5.38
11	NAU	1,079	790	130	3.42
12	NAU	729	441	113	3.05
13	NAU	818	546	180	3.00
1	COOU	1,458	835	184	3.65
2	COOU	848	482	144	3.71
3	COOU	1,459	986	215	3.34
4	COOU	758	288	96	4.19
5	COOU	1,214	1,013	207	3.13
6	COOU	1,210	916	137	4.00
7	COOU	1,405	900	142	4.59
8	COOU	1,508	1,217	249	3.63
9	COOU	1,228	655	173	4.38
10	COOU	1,393	940	254	4.31
11	COOU	4,610	3,970	471	4.50
12	COOU	2,326	1,551	368	3.60

IV. RESULTS AND DISCUSSIONS

4.1 Normality output

As in Figure 1, the normality plot in Figure 1 was used to test for the normality of the observed data. It reveals that the data is normally distributed and, as such, needs no transformation before regression analysis can be carried out with it.

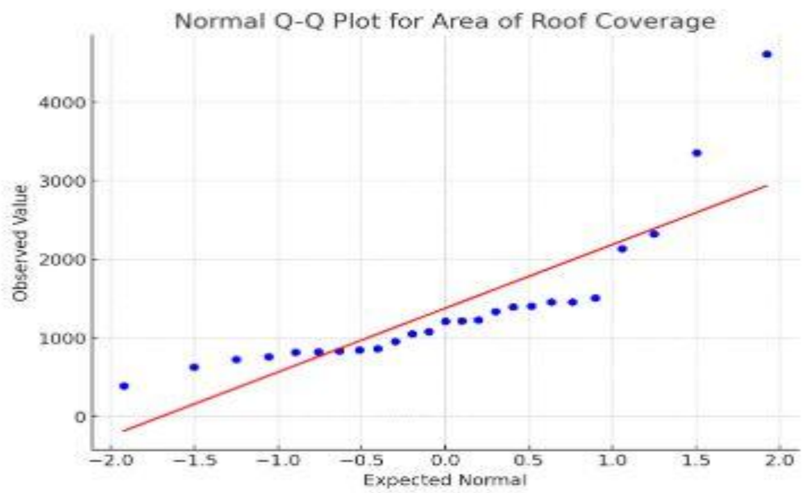

Figure 1: Normality plot of area of roof covering

4.2 Descriptive statistics

The descriptive analysis result in Table 4.1 shows the research variables' mean, standard deviations, skewness, kurtosis, and Jarque-Bera normality estimates. From the result, the Area of Roof Coverage (ARCOV) stood at average of 1376.76 m^2 with a standard deviation of 915.64m^2. The average Gross Floor Area (GFAREA) is 946.24m^2 with a standard deviation of 743.51m^2; External Block wall centre line Girth (EBCGIRTH) averaged 190.92m with a standard deviation of 97.35m; while the average pitch value is 4.01m with a standard deviation of 0.99m.

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Table 4.1: Description of the Research Variables

Statistic	ARCOV	GFAREA	EBCGIRTH	PITCH
Mean	1376.760	946.2400	190.9200	4.006400
Median	1210.000	835.0000	173.0000	3.710000
Maximum	4610.000	3970.000	471.0000	6.720000
Minimum	390.0000	267.0000	79.00000	2.000000
Std. Dev.	915.6433	743.5137	97.34643	0.987711
Skewness	2.217546	2.867736	1.483899	0.735957
Kurtosis	7.893302	12.15160	4.622528	3.927946
Jarque-Bera	45.43171	121.5077	11.91710	3.153768
Probability	0.000000	0.000000	0.002584	0.206618
Sum	34419.00	23656.00	4773.000	100.1600
Sum Sq. Dev.	20121665	13267505	227431.8	23.41378
Observations	25	25	25	25

4.3 Regression Model for Quantifying the Area of Roof Coverings of Tetfund Buildings

Table 4.2 shows that the Pearson correlation is 0.768 which is > +0.5, hence indicating a strong positive relationship between Gross floor area and Roof Covering, as well as when comparing with the p-value against 0.05, we deduce that the p-value (0.000) < 0.05, which denotes that a statistically significant relationship exists between Gross floor area and Roof Covering. Looking at Table 4.3, the correlation analysis of Blockwork Centerline Girth with Gross Floor Area reveals a strong correlation, with a superior Pearson correlation measure of 0.892 which is statistically significant at the 0.01 level (2-tailed). This indicates that an increase in Blockwork Centerline Girth increases Gross Floor Area.

Table 4.2: Table of Correlation between Gross Floor Area and Roof Covering

		Gross Floor Area	Area of Roof Covering
Gross Floor Area	Pearson Correlation	1	.768**
	Sig. (2-tailed)		.000
	N	25	25
Area of Roof Covering	Pearson Correlation	.768**	1
	Sig. (2-tailed)	.000	
	N	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.3: Table of Correlation between Blockwork Centerline Girth and Gross Floor of Roof Covering

		Blockwork Centreline Girth	Gross Floor Area
Blockwork Centreline Girth	Pearson Correlation	1	.892**
	Sig. (2-tailed)		.000
	N	25	25
Gross Floor Area	Pearson Correlation	.892**	1
	Sig. (2-tailed)	.000	
	N	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

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4.4 Predictive Model for Area of Roof Covering

Table 4.4: Predictive model for Area of roof coverage (ARCOV) of TETFund buildings dependent on Gross floor area (GFAREA), external block wall centreline girth (EBCGIRTH), and PITCH

Model Summary						
Multiple R	0.982					
R Square	0.965					
Adjusted R Square	0.960					
D-W Stat.	2.073					
F-Stat.	191.146					
Prob.(F-Stat.)	0.0000<0.05					
Coefficient & estimates; Dependent variable = ARCOV						
Variables	Coefficients	Std. Error	t-Stat.	P-value	Tolerance	VIF
Intercept	-449.822	199.884	-2.250	0.0353	==	==
GFAREA	0.738299	0.121817	6.060749	0.0000	0.172	5.816
EBCGIRTH	3.750215	0.930355	4.030950	0.0006	0.172	5.816
PITCH	102.8311	39.74915	2.587002	0.0172	0.915	1.093

The multiple regression result in Table 4.4 above shows the predictive power of GFAREA, EBCGIRTH, and PITCH on the ARCOV of TETFund buildings in Anambra State. The regression coefficient for GFAREA is 0.738, indicating a positive relationship with ARCOV, while the corresponding p-value of 0.000<0.05 revealed that this relationship is statistically significant. For EBCGIRTH, the coefficient is 3.750, showing a positive effect on ARCOV, with a p-value of 0.0006<0.05, which is also statistically significant. The coefficient for PITCH is 102.831 with a p-value of 0.0172<0.05, implying a significant positive influence on ARCOV. The overall implication of the result is that GFAREA, EBCGIRTH, and PITCH contribute significantly to the ARCOV of the buildings (F-stat. = 191.146, p<0.001).

The functional relationship is presented thus: $ARCOV = -449.822 + 0.738GFAREA + 3.750EBCGIRTH + 102.831PITCH$.

The above equation shows that, if for instance Gross floor area (GFAREA), external block wall centerline girth (EBCGIRTH), and PITCH are known, the area of roof coverage (ARCOV) can be obtained and predicted by appropriate substitution into the equation.

The model summary reveals an R-squared value of 0.965, indicating that 96.5% of the variations in ARCOV are accountable by GFAREA, EBCGIRTH and PITCH. This suggests that the model has high explanatory power, and however, has high predictive power. The autocorrelation statistic with Durbin Watson's estimate of 2.073 affirmed that the model is free from serial autocorrelation problems.

V. CONCLUSION

This study successfully developed a regression model to predict roof covering areas in TETFund projects, using gross floor area, external blockwork centerline girth, and roof pitch as key predictors. The model demonstrated a strong predictive capacity, with 96.5% of variations in roof-covering areas accounted for by these variables. The practical application of this model will significantly enhance the accuracy of cost estimations during the sketch design stage, mitigating the risks of budget overruns and project delays commonly associated with TETFund building projects. It underscores the importance of integrating data-driven tools into quantity surveying practices to achieve optimal resource utilization and improved project delivery outcomes in tertiary education infrastructure. Future research should explore the model's applicability to other public building projects across diverse regions.

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