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An Evaluation of the Predictive Validity and Time Saving Potential of a Roof Covering Quantification Model

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Abstract: Quantification of roof covering often poses a challenge for quantity surveyors/construction estimators and builders due to their time consuming nature. The study was aimed at assessing the predictive efficiency and time saving potential of a regression model in generating the approximate quantities of installed roof covering using the roof covering area on plan as the independent variable. Thirty architectural drawings (roof plans and sections) comprising eleven bungalows, sixteen duplexes and three storey buildings were randomly selected and the quantities of the roof area on plan were measured. The time spent by a group of proficient quantity surveying graduates to apply the model in comparison with the traditional take-off method was also recorded. Pearson Correlation and Student t-test were employed to test the hypotheses. Results reveal that the mean difference between the modeled quantities and installed roof covering quantities are 320.7000 and 322.4667 respectively. The results also show that the p-value of 0.009 is less than the alpha value of 0.05, indicating rejection of the null hypothesis, implying that the model saves time for quantification. The Coefficient of Correlation (R) of 0.990 suggests a very strong relationship between the area of roof covering on plan and the area of installed roof covering, implying that the model accurately predicts approximate quantities of the installed roof covering. The study concludes that the model is a realistic alternative for generating approximate quantities of installed roof covering as long as the pitch criteria of 25^0–39^0 are met. It was advanced that quantity surveyors/construction estimators and builders use the model for estimation during the planning and design stages of projects, especially when time is of the essence.

Keywords: Roof covering, Approximate estimating, Quantification, Model, Quantity Surveyor

1. Introduction

Roof covering are materials in a building over the roof deck. The type of covering used depends on the roofing system specified to waterproof the structure properly [1]; [2]; [3]; [4]. Since the 1950’s, efforts have been made in order to understand the cause- effects relationship between the design parameters and building costs, and to develop quantity models in order to estimate building cost[5] [6] defines cost modeling as a symbolic formation of a system and the contents defined with the factors affecting the cost. According to their historical development, cost models can be classified in three groups. The first generation models originated from functional elements of building oriented cost planning approach in England at the end of 1950’s and was extensively used until the end of 1960’s. The second-generation models were derived from regression analysis and have been used since mid 1970’s. The third-generation models started to develop in the beginning of 1980’s based on Monte Carlo simulation technique [5]; [7].

The reliability and accuracy of conceptual quantity estimating models are major concerns for clients and quantity surveyors [8]. Previous studies applied scoring methods and established common rules or mathematical methods to assess the quality of approximate estimates. However, those approaches have some limitations in adapting to the real world projects and require understanding of sophisticated statistical techniques [6]; [5].

The Linear Regression Model (LRM),which this study proposes is a simple, easy-to-use, and easy-to-understand model for the quantification of roof coverings for residential buildings. The LRM was obtained by eliciting quantification experience and knowledge in the take-off/measurement of roof coverings. Residential buildings can range from small simple single storey dwellings to complex schemes of high rise development and so does their roof pitches, depending on the design [9]. Hence, the quantity the roof covering is a function of the pitch or slope angle. For effective measurement, a detailed roof design should always be provided, but where this is not available, the dimensions of the roof should be calculated from those shown on the floor plans. It will be proper to prepare a roof plan, preferably superimposed on the floor plan and to carefully mark the gables, hips and valleys involved in pitched roofs and the rolls, drips and gutters involved in flat roofs [10].

The quantity model validated by this study was developed by [11] and predicts the approximate quantities of installed roof covering of residential buildings using the roof covering quantities on plan as the independent variable. The findings from the study are as follows: (i) the coefficient of correlation ‘r’ is 0.95, implying a 95% relationship between the variables. The coefficient of determination R square of is 0.809, suggesting that 80.9% of the dependent variable is explained by the independent variable. This also implies that 19.1% of the dependent variables are explained by other independent variables which are not included in the model. Given this statistics using the above stated coefficients, [11] concludes that the model is a realistic alternative for generating approximate quantities of installed roof covering using only four sets of data (since he tested the model using only four architectural drawings). This study however tests this claim using a new data set.

Developing an accurate cost estimate is the first step for successful building delivery and it incorporates measurement of works like roofing [10]. A contractor who estimates poorly will ultimately fail, no matter how well his technical capacity and skills maybe. If he underestimates his costs, he will find himself either using his profit from past project(s) to complete the job or making unnecessary claims or executing the work poorly or even abandoning the works. It is thus, expected that the findings of this study will be beneficial to clients and contractors in determining the preliminary cost estimate cost for roof covering thereby helping them in establishing realistic budgets. The application of a model for quantifying roofs in residential buildings will also be of great import to quantity surveyors in the absence of detailed design and when there is pressure of time. With the roof plan of the proposed project available, the quantities of the installed roof covering can be generated.

It is against this background that the study sought to validate the reliability and time saving potential of the LRM by analyzing the gap between LRM and the traditional take-off process in order to ascertain if the quantities are within the acceptable accuracy range.

1.1. Aim and Objectives of the Study

The aim of this study is to evaluate the efficiency of an approximate quantity model (AQM) for quantifying roof coverings for residential buildings. The objectives are:

- To evaluate the reliability of the quantities emanating from the model
- To assess the time saving potential of the AQM

1.2. Hypothesis

The following hypotheses were also validated in course of the study:

- H_0: Modeled roof covering method does not save time in quantification of installed roof covering quantities
- H_0: There is no significant relationship between roof covering area on plan and installed roof covering area.

2. Methodology

Data generated for this study, which was used for the evaluation of the model was obtained via taking-off/measurement or quantification of roof members. This involved measurement of the quantities of installed roof covering and roof covering area on plan. Thirty architectural drawings (roof plans and sections) were selected at random for residential building of not more than six floors, comprising eleven bungalows, sixteen duplexes and three storey buildings for this purpose. The measured quantities were further given to professional Quantity Surveyors to validate. To determine the time saving potential of the Model, a group of proficient quantity surveying graduates where requested to use the Model in measuring the roof covering and use the traditional take-off process to measure the same roof works, and the time spent in carrying out each task was recorded.

2.1. Data Analysis

Data for this study was analyzed using regression analysis and the Student T-test.

2.1.1. Pearson Correlation and Regression Analysis

Pearson correlation analysis is a widely used statistical tool that is used to measure the extent or degree of relationship between two variables. For this study, Pearson Correlation analysis was used to investigate the relationship between the approximate quantities of the model and the predictor variables. The formula for Pearson correlation coefficient is expressed as:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[(n\sum x^2 - (\sum x^2)(n\sum y^2 - (\sum y)^2)]}} \quad (1)$$

When $y < +0.5$, a weak positive relationship exists
When $y \geq +0.5$, a strong positive relationship exists
When $y < -0.5$, a strong negative relationship exists
When $y \leq -0.5$, a weak negative relationship exists
When $y = +1$, a perfect positive relationship exists
When $y = -1$, a perfect negative relationship exists

When $y = 0$, no relationship exists.

Regression analysis on the other hand is used to predict one variable based on another variable. It may also be said to be a technique that will find a formula or mathematical model which best describes some set of data collected. The factor whose value we wish to estimate (e.g. aggregate scores) is referred to as dependent variable and denoted by Y. the factor from which these estimates is made is called the independent variable and is denoted by X. Therefore the relationship between the dependent and independent variables could be expressed in a linear equation model as:

$$Y = a + b x \quad (2)$$

Where: Y is the dependent variables or quantity being predicted
X = the independent variables
a = the value of Y when = 0, i.e. the interceptor of the line with Y – axis
b = the slope or gradient. It estimates the rate of change in Y for a unit change in X. It is positive for direct and negative for inverse relationships.
For this study, the following regression model developed by [11] was validated for predicting the quantity of roof covering.

$$CI = e + mCP = 38.051 + 1.062CP \quad (3)$$

Where: CI = Installed roof covering area (m^2)
e = constant =38.051
CP = Roof covering area on plan (m^2)

2.1.2. Student t-test

Student t test is a statistical test which is widely used to compare the mean of two groups of samples. It is therefore to evaluate whether the means of the two sets of data are statistically significantly different from each other. It is expressed as:

$$t = X_1 - X_2 / \sqrt{SD_1/N_1 + SD_2/N_2} \quad (4)$$

$$SD = \sqrt{\sum(x - x)^2/N} \quad (5)$$

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Where:
X_1 = mean for sample/data 1
X_2 = mean for sample/data 2
N_1 = number of data collected in sample 1
N_2 = number of data collected in sample 2
SD_1 = standard deviation for sample 1=$\sqrt{\sum(x_1 - x_1)^2/N}$
SD_2 = standard deviation for sample 2=$\sqrt{\sum(x_2 - x_2)^2/N}$

3. Data Presentation and Results

The approximate quantities for installed roof covering and roof covering quantities on plan and the modeled time duration time saving potential are as shown in Tables 1 and 2 respectively. The results of the analysis are also presented to validate the approximate quantities model (AQM) which is the crux of this study.

Table 1. Measured quantities of surveyed roof coverings.

Project ID	Building type	Pitch	Cqtyi (m^2)	Cqtyp (m^2)	Mqty (m^2)
P1	A	32^0	203	172	222
P2	A	32^0	238	202	253
P3	B	34^0	339	281	337
P4	B	27^0	277	236	289
P5	C	36^0	292	234	287
P6	B	39^0	244	219	271
P7	B	30^0	268	258	312
P8	B	34^0	433	369	430
P9	B	31^0	226	193	243
P10	C	32^0	559	479	547
P11	B	31^0	177	149	196
P12	A	32^0	46	39	80
P13	B	32^0	236	151	198
P14	B	36^0	227	185	235
P15	A	32^0	583	483	551
P16	A	31^0	305	261	315
P17	A	28^0	166	144	200
P18	B	32^0	317	238	291
P19	A	30^0	356	267	322
P20	B	29^0	262	235	288
P21	A	31^0	258	217	269
P22	B	32^0	513	432	497
P23	A	32^0	431	356	416
P24	A	32^0	293	247	300
P25	B	27^0	259	222	274
P26	B	37^0	455	363	424
P27	C	32^0	506	431	496
P28	A	29^0	479	401	464
P29	B	27^0	377	316	274
P30	B	32^0	295	240	293

A= Bungalow; B= Duplex; C= Storey Building; Cqtyi= quantity of installed roof covering; Cqtyp= quantity of roof covering on plan; Mqty= modeled quantity of roof covering
Source: Researchers' field survey and computation (2017).

Table 2. Modeled duration time saving potential

Project	Modeled duration	Modeled	Traditional duration	Traditional	Difference
P1	10:01 – 10:12	11mins	07:00 – 07:19	19mins	- 8mins
P2	10:29 – 10:38	9mins	02:48 – 3:00	12mins	-3mins
P3	10:53 – 11:37	44mins	07:43 – 08:45	1hr2mins	-18mins
P4	01:00 – 01:29	29mins	08:45 – 09:20	35mins	-6mins
P5	01:32 – 01:57	25mins	09:50 – 10:19	29mins	-4mins
P6	10:43 – 10:55	12mins	08:12 – 08:34	22mins	-10mins
P7	11:16 – 11:27	11mins	09:38 – 09:57	19mins	-8mins
P8	12:30 – 12:53	23mins	04:00 – 04:27	27mins	-4mins
P9	12:04 – 12:15	11mins	05:20 – 05:35	15mins	-4mins
P10	11:14 – 11:33	18mins	11:44 – 12:11	27mins	-9mins
P11	07:15 – 07:30	15mins	10:17 – 10:50	33mins	-18mins
P12	11:00 – 11:05	5mins	11:23 – 11:30	7mins	-2mins
P13	01:03 – 01:27	25mins	01:40- 02:22	44mins	-19mins
P14	11:54 – 12:58	10mins	11:36 – 11:56	14mins	-4mins
P15	12:41- 12:58	17mins	12:06 – 12:36	30mins	-13mins
P16	02:09 – 02:16	7mins	01:59 – 02:08	9mins	-2mins
P17	03:21 – 03:32	11mins	02:46 – 03:07	21mins	-10mins
P18	05:14 – 05:30	16mins	04:48 – 05:10	22mins	-6mins
P19	06:04 – 06:22	18mins	05:10 – 05:40	30mins	-12mins
P20	05:37 – 05:47	10mins	05:15 – 05:32	17mins	-7mins
P21	06:25 – 06:36	11mins	05:52 – 06:25	33min	-11mins
P22	07:02 – 07:13	11mins	06:38 – 06:56	18mins	-7mins
P23	02:41 – 03:00	19mins	01:59 – 02:30	31mins	-12mins
P24	03:27 – 03:38	11mins	03:06 – 03:22	16mins	-5mins
P25	10:52 – 11:10	18mins	10:17 – 10:45	31mins	-13mins
P26	12:29 – 12:44	15mins	11:14 – 11:45	31mins	-16mins
P27	01:57 – 02:05	8mins	01:43 – 01:56	13mins	-5mins

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P28	03:52 – 04:05	13mins	03:24 – 03:45	21mins	-8mins
P29	07:48 – 08:08	20mins	04:57 – 05:38	41mins	-21mins

Source: Researchers' computation (2017).

Table 2 reveals that on all surveyed roof works, the modeled roof covering method saves time when compared to the traditional method of taking-off in generating roof covering.
With the least time difference of 2 minutes and the highest, being 21minutes.

3.1. Evaluation of the predictive validity of the Model and validation of hypothesis

Table 3.SPSS output of statistical results

Paired Samples Statistics								
	Mean	N	Std. Deviation	Std. Error Mean				
Pair 1 RCQ & MQ	320.70000 322.4667	30 30	125.79407 112.16482	22.96675 20.47840				
	Paired Samples Correlations							
	N	Correlation	Sig.					
Pair 1 RCQ & MQ	30	.990	.000					
	Paired Samples Test							
	Paired Differences							
	Mean	Std Deviation	Std Error Mean	95% Confidence Interval of Difference				
				Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 RCQ & MQ	1.76667	21.72982	3.96730	-9.88071	6.34738	-.445	29	.009

Source: Researchers' computation using SPSS Ver. 21.

Decision rule: Accept the null hypothesis when the probability value is greater than the alpha value, otherwise reject; **Level of significance = 0.05**

From the analysis in Table 3, the mean difference between the modeled quantities (MQ/Mqty) and installed roof covering quantities(RCQ/Cqty) are 320.7000 and 322.4667respectively. The results also show that the probability value (0.009) is less than the alpha value (0.05), indicating rejection of the null hypothesis and acceptance of alternative hypothesis. This implies that the modeled roof covering method saves time in quantification of installed roof covering quantities.
The Coefficient of Correlation (R) is 0.990 which indicates that's there is a 99% relationship between the independent variable(roof covering area on plan) and the dependent variable (installed roof covering area) This is indicates a very high level of correlation and thus significant relationship between both variables. The implication of this is that the modeled roof covering method predicts approximate quantities of the installed roof covering where the roof area on plan is known.

4. Conclusion and Recommendations

This paper assessed an approximate quantity model (AQM) which is beneficial in obtaining the quantities of installed roof coverings. This will in turn help to advice the client and architect on the cost implications of a proposed roofing works at the planning and design stages, especially, when limited information is available and time is of the essence. It also provides an insight into the relationship between installed roof covering quantities and the plan shape of the upper floor of a building. This study concludes that this model is very useful in application because of its simplicity.

It is however pertinent to note that approximate quantities is not the exact quantities for an item of work, but it gives a value that is close to the real value(plus/minus5%) when detailed measurement is carried out. This model works for residential buildings only with long span aluminum roofing sheet. The pitch of such roof must be within the range of 25^0 and 39^0. Therefore, the determination of the approximate quantities of roof covering of any proposed residential apartment must fulfill the conditions of the model, since the quantity is a function of the pitch. It is hereby advanced that quantity surveyors/construction estimators, contractors and builders to use the model in predicting the approximate value of roof covering quantities.

References

i. *R. Barry, The construction of buildings, Vol. 3, London: Blackwell Science Ltd, 1993.*
ii. *R. Mike, and C. Alison, Construction technology 2: Industrial and commercial buildings, New York: Palgrave Macmillan, 2004.*
iii. *S. Emmit, and C.A. Gorce, Introduction to construction of buildings, Oxford, UK: Blackwell Publishing Ltd, 2005.*
iv. *E. Fleming, Construction technology, an illustrated introduction, Oxford, UK: Blackwell Publishing Ltd, 2005.*
v. *Y. E. Hakan, A building cost estimation model based on functional elements, Journal of Istanbul Technical University, Faculty of Architecture, Istanbul, Turkey, 2007.*
vi. *I.H. Seeley, Building economics, UK: Palgrave Macmillan, 1981.*
vii. *M. Ibrahim, Conceptual cost estimating of road construction projects in Saudi Arabia, Jordan Journal of Civil Engineering, 7 (3), pp. 61–66, 2007.*
viii. *O.O. Temitope, A predictive model for the determination of the final cost of construction projects, Unpublished B. Tech Thesis, Department of Quantity Surveying, Federal University of Technology, Akure, 2001.*
ix. *J.A. Fadamiro, and D.R. Ogunsemi, Fundamentals of building design, construction and materials, Akure, Ondo State: Adeyemo Publishing, 1996.*
x. *O. Olomi-Ojo, Estimation of unit rates and material schedules for roofing works, A lecture delivered at TONS Development Ltd, 2nd Floor, Cocoa House, Dugbe, Ibadan, 2013.*
xi. *O. Lekan, Modeling the quantities of roof covering of residential buildings in Ondo State, Nigeria, Unpublished B. Tech Thesis, Department of Quantity Surveying, Federal University of Technology, Akure, 2014.*

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