การหาตัวคูณค่าคงที่เพื่อช่วยเป็นเครื่องมือในการประมาณราคางานผนังของบ้านพักอาศัย 2 ชั้น

Develop an Estimating Factor to Help Estimating Masonry Wall Area of Two Stories Houses

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บทคัดย่อ

ขั้นตอนที่ใช้ระยะเวลานานและยุ่งยากซับซ้อนมากในการประมาณราคางานก่อสร้าง คือ ขั้นตอนการหาปริมาณวัสดุ การหาพื้นที่ผนังสำหรับงานก่อสร้างเป็นกระบวนการที่ยุ่งยาก หากมีเครื่องมืออย่างง่ายที่สามารถช่วยหาปริมาณวัสดุในงานผนังก็จะช่วยลดเวลาทำงานของนักประมาณราคาลง ผู้วิจัยจึงสนใจที่จะศึกษาความสัมพันธ์เชิงสัดส่วนของพื้นที่ผนังอิฐก่อต่อพื้นที่อาคาร โดยเลือกแบบบ้านพักอาศัย 2 ชั้น ขนาดเล็ก จำนวน 59 แบบเป็นกรณีศึกษา ใช้วิธีการวิเคราะห์การถดถอยเชิงเส้นพหุคูณ วิเคราะห์หาตัวแปรอิสระที่มีอิทธิพลต่อตัวแปรตาม พบว่า พื้นที่อาคารเป็นตัวแปรอิสระที่มีผลต่อพื้นที่ผนังอิฐก่อ จากการนำแบบจำลองที่ได้มาทดสอบ พบว่า พื้นที่ผนังอิฐก่อ น้อยกว่าการประมาณราคาแบบละเอียด 0.50 – 6.78 เปอร์เซ็นต์ ดังนั้นแบบจำลองที่ได้จากการศึกษาวิจัยในครั้งนี้ สามารถนำไปใช้ในการประมาณราคาและตรวจสอบความถูกต้องของการหาพื้นที่ผนังของอาคารโครงการใหม่ได้ในเวลาอันรวดเร็ว

คำสำคัญ: สัดส่วน ก่อสร้าง ผนัง

Abstract

The most complicated and time-consuming step in estimating construction costs in determining the amount of material is a calculation of all areas for masonry works involving tedious processes. A simple estimating tool could assist estimators in estimating the amount of materials with reducing working time. The purpose of this research is to study the proportion of the masonry wall quantity to the building's area and develop an estimating factor to estimate the masonry wall area of two-stories houses in 59 drawing

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construction for a case study. Using multiple linear regression analysis for independent variables that influence the dependent variable showed that the building area was an independent variable affecting the masonry wall area. The modeling to test, found that the masonry wall area less than the detailed estimation as 0.50 - 6.78 %. Therefore, the model derived from this research, therefore can apply for cost estimation and validation of the masonry wall area calculation of new project quickly.

Keywords: Proportion, Construction, Masonry Wall

Introduction

Cost estimation in construction is the first important step taken before the construction process begins [1]. Acquisition of a quick and accurate construction cost will have a positive effect on the decision making of the project [2]. Also, it is an indicator of the success of the contractor or project owner whereas an incorrect estimation will not reflect the actual cost only but may cause a deficit also [3]. The reasons for cost estimation include setting a construction budget [1], considering the incentives and feasibilities of the investment, controlling the cost and determining the average cost of the construction project [4] and considering the increasing or decreasing of work during construction for the project manager, etc. [5].

Estimating construction cost can be divided into 2 main categories. First, a rough or initial cost estimation is generally used to estimate the initial cost or the amount of money the owner has to prepare [6]. It is the first step taken in budget planning for a new project, which is performed quickly, however, it lacks accuracy. Second, a detailed estimation is carried out after having a detailed design and list of specifications. Usually, this is carried at done by the contractor and is used for project bidding, or by the owner who uses it for estimating the average cost, or for controlling the progressive drawdown to the contractor [6]. Detailed estimation requires a construction expert and takes a long time to find the amount of work [1], all depending on the conditions of time, experience and expertise of the cost estimator [7].

The study of proportional relationships is another popular approach to cost estimation. From past research, it was found that there are various studies such as the proportion of concrete to reinforcement [9]. The Study of the proportion of increased reinforcement in earthquake-resistant buildings [10-15]. The Study of construction cost per building area [16]. The study of the proportion in road construction [17]. The study of the formwork per total area, reinforcing bar per concrete, formwork per concrete, steel roofing per formwork, steel roofing per roofing [8,18]. The study a functional area-based cost estimation model of reinforced concrete residential buildings [19]. From past research studies, it was found that there was still a lack of study on the relation between wall area to the building area. Buildings where finding the cost of the wall area in estimation is another long and complicated activity. The accuracy of the quantity of building materials is also important in estimating the construction cost. So, if there is a simple tool and convenient to use, to reduce the working time. The researcher is interested to study the relationship between the masonry wall area to the building area and develop a tool to quantify wall materials. By choosing a small two - storey house as a case study.

Materials, Equipment and Research Method

Purpose of Cost Estimates

The construction cost estimates are involved in the process at the beginning and during the building process of the project. The objectives of the cost estimates differ in each stage as follows: (1) Project budgeting is generally carried out by the project designer to determine the average cost for construction costs, which to be used as a basis for evaluating the cost of bidders during the process of submitting a tender. (2) Determining the construction progress payments is proceeded by the supervisor or representative of the project owner, based on the plan. In order to determine the installments and for the convenience of disbursement of the work, in some cases, the actual workload must be calculated and identified. This requires on-site surveys before the cost evaluates to be paid in that period. (3) Changing order and extra work payment has occurred in cases where the owner requires the contractor to work in addition to the design and specifications of the contract. An estimate of the additional workload from the variations made to the design, with the unit price used to calculate may be inferred from the cost shown in the quotation or a new unit cost depending on the conditions specified in the contract. (4) Feasibility study does not need to have to be in a detailed format. This may be done by calculating the cost per unit of living space or of use, which is acceptable in analyzing the feasibility of the project before proceeding to the next step. (5) Bill of quantities for competitive bidding is prepared by contractors, and the estimates must be done carefully and prudently, otherwise, it may cause loss [20].

Guidelines for Measuring of a Masonry Wall

An approach to measuring the amount of masonry wall work is to calculate the length of the masonry wall from the edge of an inner side of one of the columns to the inner side of the other column. In case of extending walls, the wall length is measured from the edge of the outer side of the column to the outer edge of the wall, and is multiplied by the height of the wall from the ground floor to the top floor or the top beam. The amount of masonry wall is measured in square meters, [21] as in Figure 1.

Figure 1 An approach to measuring the amount of masonry wall

The Engineering Institute of Thailand has suggested a way to measure the amount of masonry wall without any deduction by reasons of the following items: (1) openings with an area not exceeding 0.10 square meter, (2) joints, (3) other objects passing through or buried in a masonry wall or block wall that have an area of the cross-section no more than 0.01 m^2, (4) lintels, tie column and (5) cornice and other surface features with an area of the cross-section no greater than 0.05 m^2 [21].

Related Statistics

1) Arithmetic Mean is the value obtained by taking the sum of all the data divided by the total amount of data, which is another way of describing each data set collected using only one number or using one value which represents the whole set of data in order to easily summarize the important details of that data set. The value can help understand the characteristics of the whole set of data [22].

2) Standard deviation is the square root of the mean square of the deviation between each data value and the data mean, or the square root of the squared deviation. The standard deviation shows how much each data is different from one another. If the standard deviation is very large, it means that each data is very different, whereas if the standard deviation is small and closer to zero, then each data is very similar [23].

3) Linear regression analysis is a statistical method used for investigating the relationship between independent variable and dependent variable is a study of linear relationship. If it investigates the relationship between one independent variable and one dependent variable, it is referred to the simple linear regression analysis. If there are more than one variables and one dependent variable, it is referred to multiple linear regression analysis. The objectives of the regression analysis are to study the relationship between independent variable and dependent variable, for example study of relationship between age and cholesterol

level and to study the relationship between factors and independent variable co-predicted the dependent variable, for example study of factors affecting blood sugar of patient with diabetes [24].

Research of Scope and Data Analysis

Construction drawings are not much published documents. Most are collected by the project owner agency. Therefore, it is a limitation in finding construction designs to be used in conducting research. The researcher chose the construction drawing that was published online on the website. That can be easily searched by choosing a 2-storey house. The Baan Yim project is for people of phase 3 of the Public works department, of which there are 59 construction drawing was used for this research. then the construction drawings were used to analyze to find the area of the building (2) the masonry wall area, (3) the opening space, and (4) the height of the masonry from details as follows:

1) Building area is the total area of the building. The unit is square meters.

2) The area of masonry wall is the width of the masonry. Multiply by the height of the masonry. Minus the opening space details as per item 2.2 and figure 1, are in square meters.

3) The opening space is the total area of the doors and windows. The unit is square meters.

4) The height of the masonry wall is the height measured from the floor level of the masonry wall to the beam or the upper floor of the wall as shown in Figure 1, in square meters.

This research determines the independent variables that influence the masonry wall area of 3 variables: building area, open space, and the height of the masonry wall. Then analyzed for independent variables affecting the dependent variables, by selecting the method of multiple linear regression analysis as shown in Table 1.

Table 1 Conceptual for multiple linear regression analysis

Independent Variable	Dependent Variable
X_1 = Building Areas X_2 = Open Space X_3 = Height of Masonry Wall	Y = Masonry Wall Areas

The Results of the Study

From the construction of a small residential building, 2 stories house, The Baan Yim Project for people at phase 3 of Public Works Department, 59 construction drawing, details are as follows: reinforced concrete structure system, tiled floor, masonry wall area, smooth plaster surface and painted. From an analyzed in data details, it was found that building area minimum below of 102.00 m^2, maximum height of 260 m^2, Average of building area 157.58 m^2, minimum masonry wall area 157.58 m^2, maximum 413.40 m^2, Average masonry area is 252.83 m^2, The minimum opening space is 43.33 m^2, maximum 120.00 m^2, the average opening space is 65.01 m^2, Masonry wall area height: minimum 2.70 m., maximum 3.20 m., average masonry wall area height 2.82 m., as shown in Table 2.

Table 2 Basic information of 59 construction drawing

Description	Min	Max	$\overline{X}$	SD
Building Areas (m^2)	102.00	260.00	157.23	37.52
Masonry Wall Areas (m^2)	157.58	413.40	252.83	56.27
Open Space (m^2)	43.33	120.00	65.01	15.86
Height of Masonry Wall (m)	2.70	3.20	2.82	0.09

Data from Table 2 is analyzed to determine the independent variable affecting the dependent variable using stepwise linear regression analysis for determining relevant variables because of this method is a method that is able to select the relevant variable efficiently, especially, in case of there is many independent variables. data is analyzed using SPSS program as shown in Table 3 – 7.

Table 3 Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Building Areas		Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100)

a. Dependent Variable: Masonry Wall Areas

Table 4 Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	.916[a]	.839	.836	22.90158

a. Predictors: (Constant), Building Areas

Table 5 Anova[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	156084.649	1	156084.649	297.597	.000[b]
	Residual	29895.507	57	524.483		
	Total	185980.155	58			

a. Dependent Variable: Masonry Wall Areas

b. Predictors: (Constant), Building Areas

Table 6 Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	33.077	13.146		2.516	.015
	Building Areas	1.383	.080	.916	17.251	.000

a. Dependent Variable: Masonry Wall Areas

Table 7 Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Open Space	.012[b]	.156	.877	.021	.505
	Height of Masonry Wall	-.003[b]	-.052	.958	-.007	.992

a. Dependent Variable: Masonry Wall Areas

b. Predictors in the Model: (Constant), Building Areas

From modeling and the data obtained from the analysis as shown in Table 3 - 7, it was found that the variable effect on the masonry wall area was the building area. For other parameters doesn't affect the masonry wall area. It is able to create a model for determining the area of masonry walls. As the first model.

$$\text{Masonry wall area (Y)} = 1.383 \text{ (building area)} + 33.077 \quad (1)$$

Testing of model, Researchers have tried to find the area of masonry. Using a detailed estimation method of a model house. There are 3 types of examples: (1) Residential house type A, a two-storey residential building, 3 bedrooms, 2 bathrooms, building area of 114.64 m^2, There is a masonry wall area equal to 192.58 m^2 (2) Residential house type B is a two - storey residential building, 3 bedrooms, 3 bathrooms, building area of 136.04 m^2, There is a masonry wall area equal to 237.30 m^2 and (3) Residential house type C is a two - storey residential building, 4 bedrooms, 3 bathrooms, building area 133.97 m^2, Masonry wall area is 228.82 m^2, The researcher calculated an area of housing type A, B and C from calculated as such substitute the value in model 1, it is found that housing type A has a masonry wall area of 191.62 m^2, The value obtained is 0.50 % less than the detailed cost estimate. B has a masonry wall area of 221.22 m^2, The value obtained is 6.78 % less than the detailed cost estimate, C housing has a masonry wall area equal to 218.36 m^2, the value is 4.57 % less than the detailed cost estimate as shown in Table 8.

Table 8 The comparison of the amount of masonry wall area

Residential house type	Building Areas (m^2)	Areas of Masonry Walls (m^2)		Difference (%)
		By Detailed Estimating	By Model	
A	114.64	192.58	191.62	- 0.50
B	136.04	237.30	221.22	- 6.78
C	133.97	228.82	218.36	- 4.57

Conclusion

According to the study of the proportionality of masonry wall area to building area of 59 construction drawing of small two - story housing construction, it was found that the minimum building area is 102.00 m^2, maximum 260 m^2, and the average building area is 157.58 m^2, The minimum masonry wall area 157.58 m^2, maximum 413.40 m^2, average masonry wall area 252.83 m^2, minimum opening space 43.33 m^2, maximum 120.00 m^2, average opening space 65.01 m^2, minimum masonry height 2.70 m., maximum 3.20 m., The average masonry height was 2.82 m. The data was analyzed for the independent variable influencing the dependent variable. By selecting the Multiple Linear Regression Analysis method, it was found that

1. The variable influencing of the masonry area was the building area while the other parameters had no effect on the masonry wall area.

2. A model for finding the area of masonry walls (Y) = 1.383 (building area) + 33.077.

3. Testing model from this research and 3 models of building samples, it was found that the area of masonry wall is less than the detailed cost estimation of 0.50 – 6.78 %, which is acceptable value because of its difference does not exceed 10 % [25].

4. The model obtained from this research can be used to estimate cost and validate the masonry wall area of a new project building in a short time.

5. A model derived from this research can be applied for validating the masonry wall area calculation of new building with area between 100.00 - 260.00 m^2

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