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STUDY OF THE INFLUENCE OF AGE TOWARD MANPOWER COEFFICIENT IN UNIT PRICE ANALYSIS

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Abstract: In unit price analysis, cost of work is calculated using its quantity and coefficients of materials, manpower and equipment. While coefficients of materials and equipment can be obtained easier, establishing coefficient of manpower is rather difficult, especially in developing countries. One of the reasons behind the difficulty is lack of performance standardization. In attempt to acquire an approach that can accommodate the uncertainty in determining coefficient of manpower, a study was conducted. The case of this study is manpower for masonry, wood and reinforced work with age as a measuring rod of manpower performance. As a reference, manpower coefficient in National Standard of Indonesia (NSI) is utilized. Data is processed to obtain the average of manpower performance and its correlation to age. Manpower coefficient of NSI is also analyzed concerning its value to the range of manpower performance gathered. The last step is determining the coefficient of manpower to be employed. This paper attempts to describe the study and the result of it.

Key Words: manpower performance, uncertainty, age, unit price analysis

1. INTRODUCTION

Prior to a project construction execution, initially the cost of it has to be estimated. The estimation cost is essential to be accomplished because it can be employed as a base in controlling process during project construction execution. In cost estimation process, there are several cost items that are required to be taken into consideration. Firstly, the cost of material that is considered necessary for the construction is calculated. The calculation of material cost is based upon the work volume of all activities in construction. The material cost estimation is derived from the knowledge of construction material utilized. The second item to be examined is the cost of manpower involved in the construction. The cost of manpower is also based on work volume as well as his productivity. Moreover, other items of the project that are necessary for the cost estimation process are construction methods,

equipment selection, overhead and profit allocation. Equipment is selected with the knowledge of construction method that is going to be executed.

Cost estimation can be derived using several methods. Common method of cost estimation in the construction is unit price analysis. In unit price analysis, the need of material, manpower and equipment for a certain work type is calculated using coefficients. For each unit of work stated in meter, square meter or cubic meter, the requirement of material, manpower and equipment is expressed in coefficients. Later, the total cost for construction is derived by multiply the coefficient with work volume.

Coefficient of material can be obtained more easily. It is due to the fact that the requirement of material for each unit of work is relatively established. Coefficient of equipment is also considered more easily to confirm. It is based on the construction method applied in the project. In some countries, manpower performance has been standardized. In this condition, coefficient of manpower can be acquired easily. It is because manpower involved in the construction industry has a certain performance standard. However, in other countries as developing ones, manpower performance has not been standardized. This condition takes place in Indonesia.

In Indonesia, a unit price analysis has been tried to formulate. The first unit price analysis known in Indonesia is BOW (*Burgeslijke Openbare Werken*) Analysis. This analysis is formulated in 1921. BOW analysis is not represented for current condition because some of materials used in it are not utilized anymore while new materials and methods are not contained in it (Rostiyanti, Anondho, 2002). Consequently, cost estimation obtained from BOW analysis cannot accurate.

Nowadays, Indonesian government, especially Agency of Research and Development, Ministry of Settlements and Regional Infrastructure has been formulated the Indonesian National Standard (NSI) for unit price analysis of housing. While this guideline of housing cost estimation is acknowledged, the application of the standard has not been widely used. As a matter a fact, many parties involved in the construction industry still utilized their own unit price analysis in cost estimation. Commonly, their unit price analysis is derived from execution of the same work repeatedly. Consequently, unit price analysis varies among the parties. The unit price analysis accomplished by the ministry, however, is derived from gathering secondary and primary data. The secondary data comes from some housing contractors and the primary one is gained from several housing projects around Bandung city, Indonesia. As a result, the NSI cannot be implemented in some areas in Indonesia.

The main problem in obtaining manpower coefficient in unit price analysis is the lack of manpower performance standard involved in the construction industry. The reason behind the lack of manpower performance standardization is labor-intensive program that has been government priority. The aim of this program is to absorb more manpower in the industry. Due to this condition, most manpower involved in the industry does not have any experience and training for a particular work. Labor intensive can lead to variation of manpower performance. The variation is affected by some factors as age, experience, origin, education level, etc. The variation leads to the uncertainty in determining performance standardization in construction industry. As a result, it is essential to define manpower performance.

In the uncertainty condition, manpower performance is difficult to determine. Many factors influence the performance, which require to be taken into account. Therefore, an approach

that accommodates the uncertainty becomes essential to establish. A study is conducted in order to obtain an approach that is suitable for uncertainty condition. The main purpose of the study is to attain manpower performance that can be utilized in calculation of manpower coefficient for unit price analysis. In this study, the research is focused on manpower that performs masonry, carpentry and reinforced works. Data is collected from housing projects. In this study, age of manpower is determined as influence factor of the performance.

2. LITERATURE REVIEW

In order to obtain labor productivity, duration of each work is established. Before duration of work is acquired, the activity sequence of a work is determined along with their relationships as requirement in developing a network diagram. Duration of work is calculated using Eqn 1.

$$T_x = t_{x_1} + t_{x_2} + t_{x_3} + \ldots t_{x_n} \tag{1}$$

In the Eqn. 1, t_{xn} is duration of activity in certain work. Using the value of *Tx* which is the total duration of work, productivity can be computed. Productivity is calculated using Eqn. 2.

$$Productivity = \frac{1}{T_x} \tag{2}$$

After productivity of each manpower is determined, the result is correlated with age using quantitative method. Quantitative method can be described using many models. One common model of quantitative method is regression model. According to Walpole and Raymond (1995), regression is a mathematical model used to predict a dependent variable by analyzing independent variable. Independent variable is symbolized in X and dependent variable in Y. In this study, regression model is applied in order to find the correlation between two variables. Independent variable in the study is age and the dependent variable is productivity. Regression model can be linear or non-linear. The study applies non-linear regression based on the assumption that manpower characteristic is not linear. Manpower productivity depends on many factors that influence it as environment and physical condition. This assumption is also applied in manpower's age. As the age increases, the physical condition does not always increase. In some point, the physical condition of manpower can be decreased. Mathematically, regression for non-linear is expressed in Eqn. 3 below.

$$Y = a + bX + cX^2 \tag{3}$$

In the equation above, *a*, *b*, *c* are integers. In order to understanding the correlation between X and Y the equation is analyzed. The correlation between X and Y is defined as correlation coefficient (*r*). The value of *r* is between –1 and 1.

After the equation is obtained, it is differentiated in order to find the optimum point of the trend line. The optimum point (X,Y) is the highest point of the trend line. The inversion of Y of the optimum point is manpower coefficient. The equation of manpower coefficient is as shown in Eqn 4.

$$coefficient = \frac{1}{Y} \tag{4}$$

3. STUDY METHODOLOGY

Methodology applied in this study is based on the assumption that actual data is a part of population that is represented by NSI. Therefore, the output of the study has to be compared with NSI in order to apply the output itself. The below methodology is step-by-step approach in conducting the study.

1. Each work is broken down into activities
Manpower coefficient is related to a specific work activity in unit price analysis of NSI. On the other hand, some activity items construct each work. Therefore, work activity has to be broken down into sequence activity items for the purpose of data collection. The work breakdown is shown in Figure 1 to 3 below.

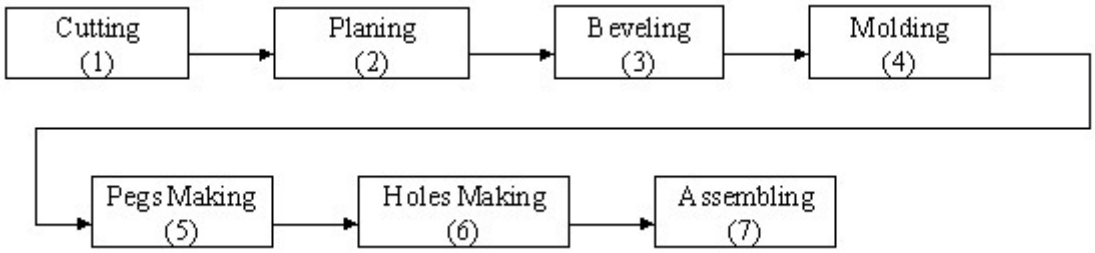

Figure 1. Activities Sequence of Door Frame Work

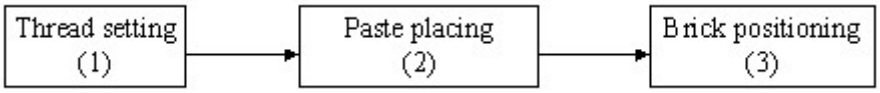

Figure 2. Activities Sequence of Brick MasonryWork

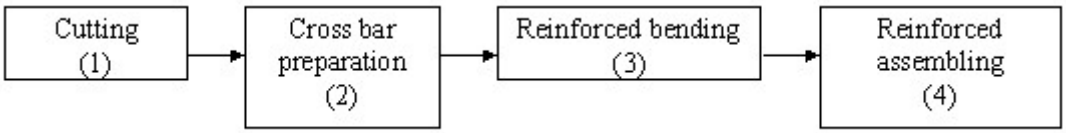

Figure 3. Activities Sequence of Reinforced Bar Work

2. Data is collected from field
Data gathered are age, duration and NSI coefficient. Age of respondent is gathered from direct interview with the sample object. During interview, data is input into table as shown in Table 1 below.

Table 1. Age of Manpower Collection Form

No.	Name	Age

Duration is obtained from observation of length of time each item activity performed and work volume resulted during that period. Duration from observation is stored into table represented below. x_1, x_2 is duration of item activity.

Table 2. Duration from Observation Form

No.	Name	Volume of Observation	Length of Time				Total Duration	Duration/volume (T_x)
			x_1	x_2		x_n		

The coefficient is obtained from NSI number 03-2495-1991, 03-3434-1994 and 03-94-03. The value of labor coefficient in Indonesian National Standard (NSI) of Construction Cost Analysis for Building and Housing for door frame, brick masonry and reinforced bar works are 18.00 man/day/cubic-meter, 1.6 man/day/cubic-meter, and 0.033 man/day/kg in that order.

3. Data is tested and processed using quantitative method
The first step in the process is testing the population. Test is undertaken to verify whether the NSI coefficient is in the range of data's sample or not. Confidence interval is applied in the test. The level of confidence interval set is 95%. Secondly, productivity is computed using Eqn. 2. After productivity is computed, correlation between age and manpower productivity is defined using regression model. The correlation is obtained after equation regression of non-linear is identified.

4. Conclusion is drawn from the analysis.

4. ANALYSIS

After data collected from the field, manpower coefficient for door frame, brick masonry and reinforced bar are calculated. Once the manpower coefficient is known, the population is tested. The hypothesis testing method will be used to analyze the assumption hypothesis that SNI coefficient is larger than data obtained. The result of the testing is shown in table below.

Table 3. Output result of data analysis

Item of Work	Maximum coefficient	NSI coefficient	Z	Result
Door frame	15.1248	18	12.00	Accept H1
Brick masonry	0.7536	1.6	4.25	Accept H1
Reinforced bar	0.012	0.033	6.07	Accept H1

Using Eqn.2, productivity for each activity will be known. The next step is to find correlation between variable age and productivity. Figure 4 to Figure 6 describe correlation between variable age and manpower productivity for different type of work. In the figures, the equation of each work along with the R^2 is shown.

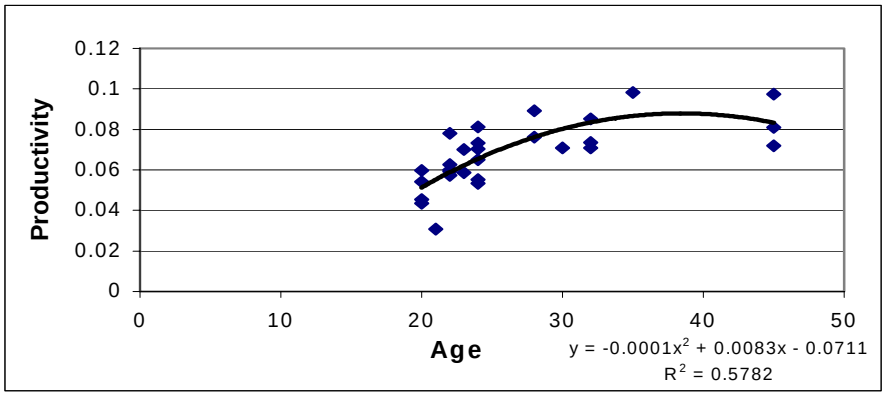

Figure 4. Correlation Age vs Productivity for Door Frame Work

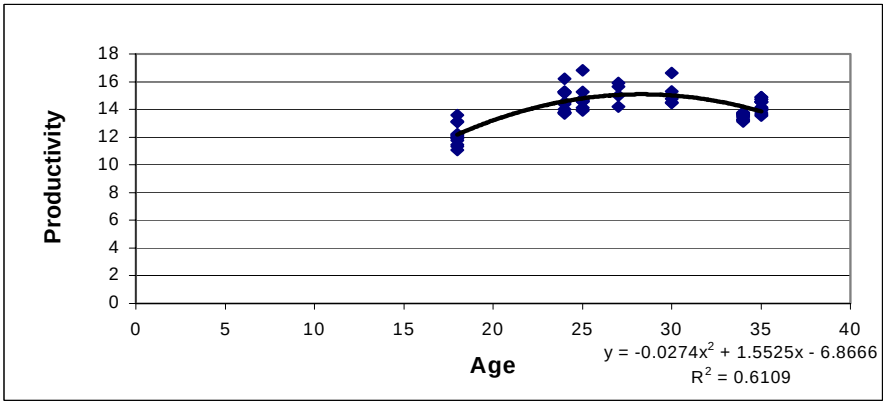

Figure 5. Correlation Age vs Productivity for Reinforced Bar

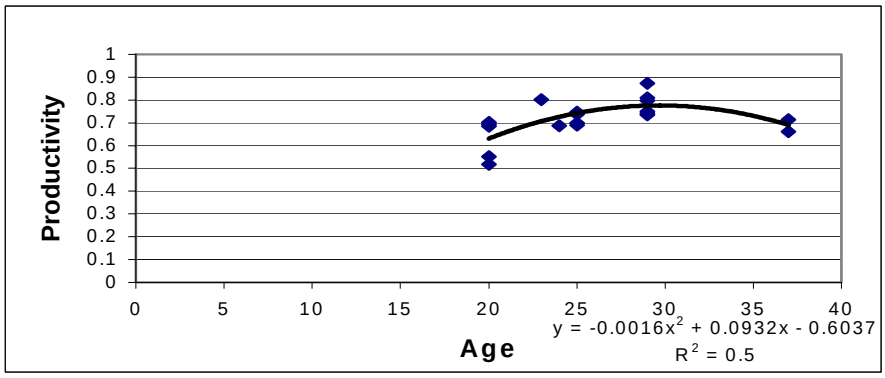

Figure 6. Correlation Age vs Productivity for Brick Masonry

1. CONCLUSION

From the study, it can be concluded as follows:

1. The analysis above shows that coefficient from observation is lower than NSI coefficient. This improves that there is variables impulse manpower productivity.
2. One of variable that impulse to manpower productivity is age. The correlation between age and manpower productivity shows decreasing productivity in certain age.
3. Curves in figure 4, 5, and 6 show that manpower productivity has positive values.

4. The value of r in the equation shown in each figure is around 0.7. It means that the correlation is considerably good for each case. Thus, it can be concluded that there is a correlation between the two variables.

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