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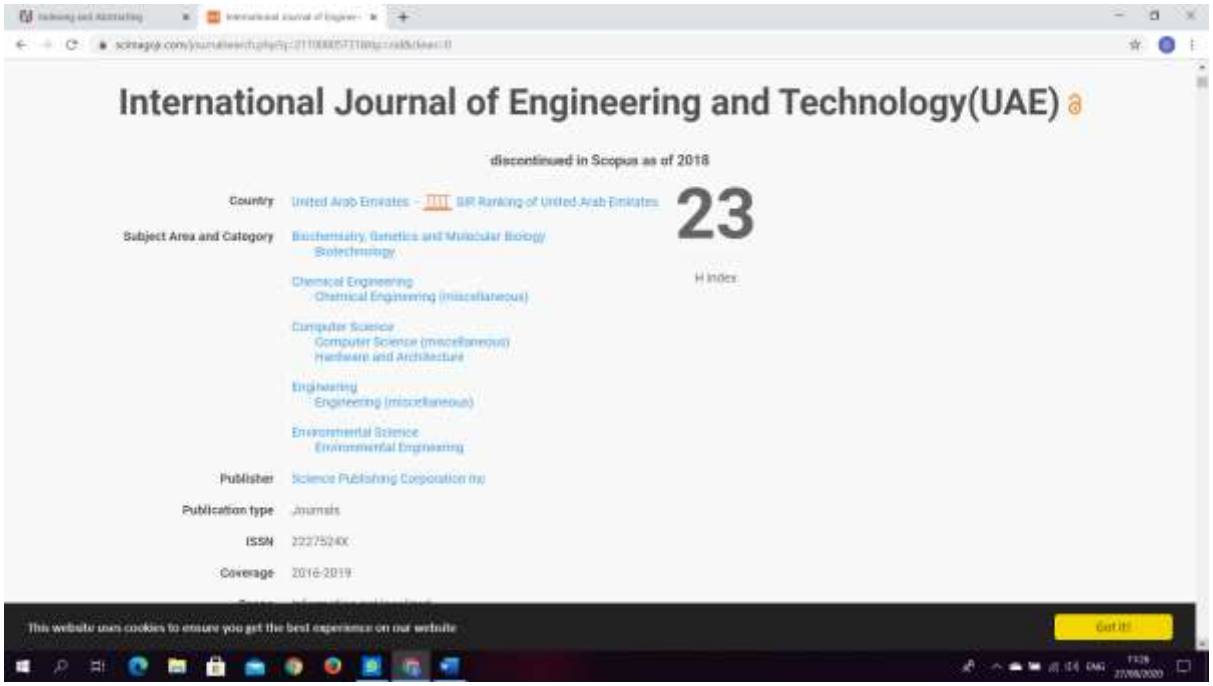
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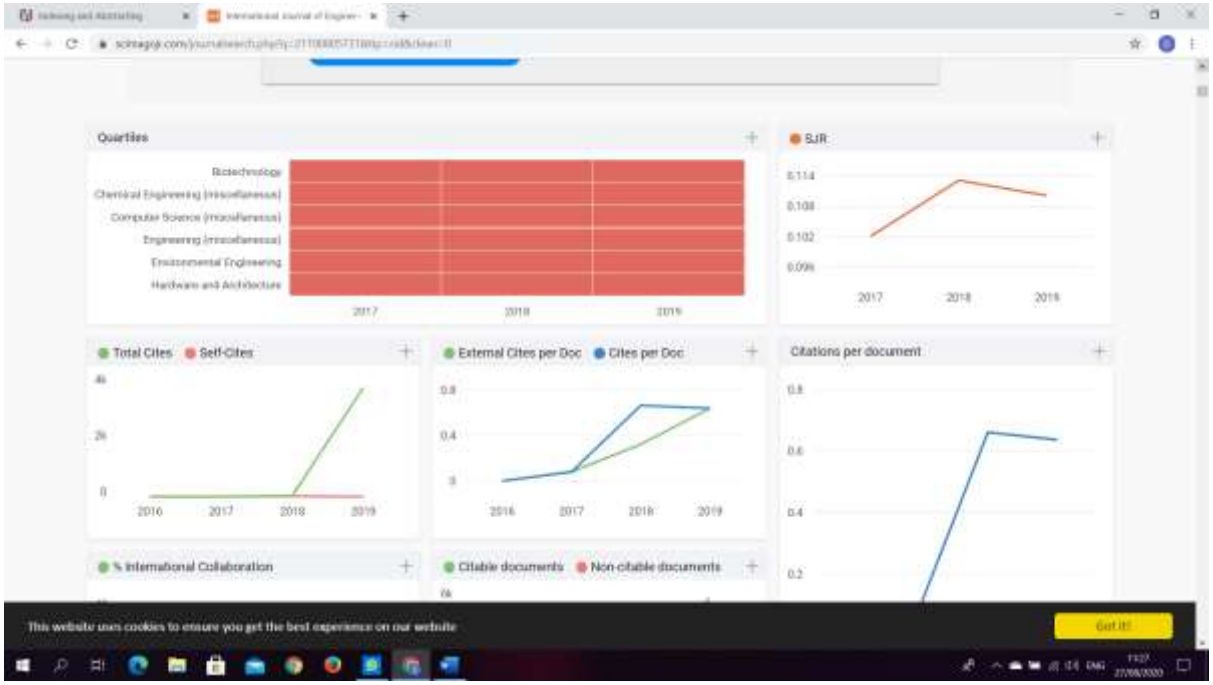
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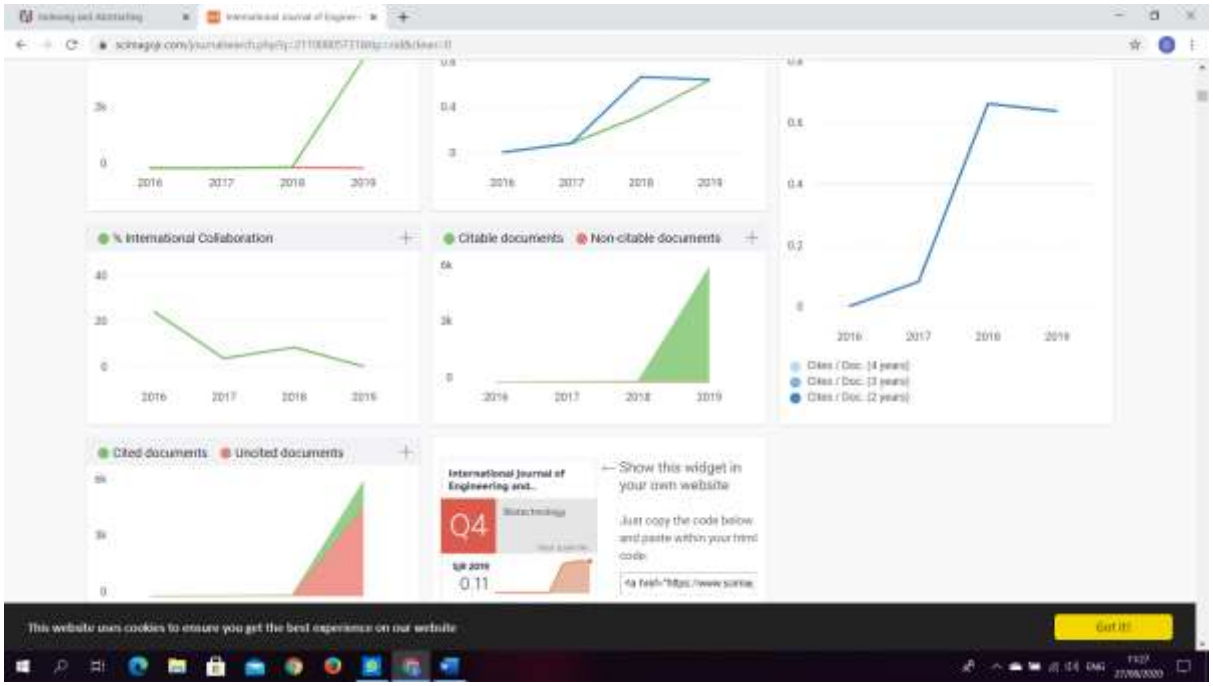

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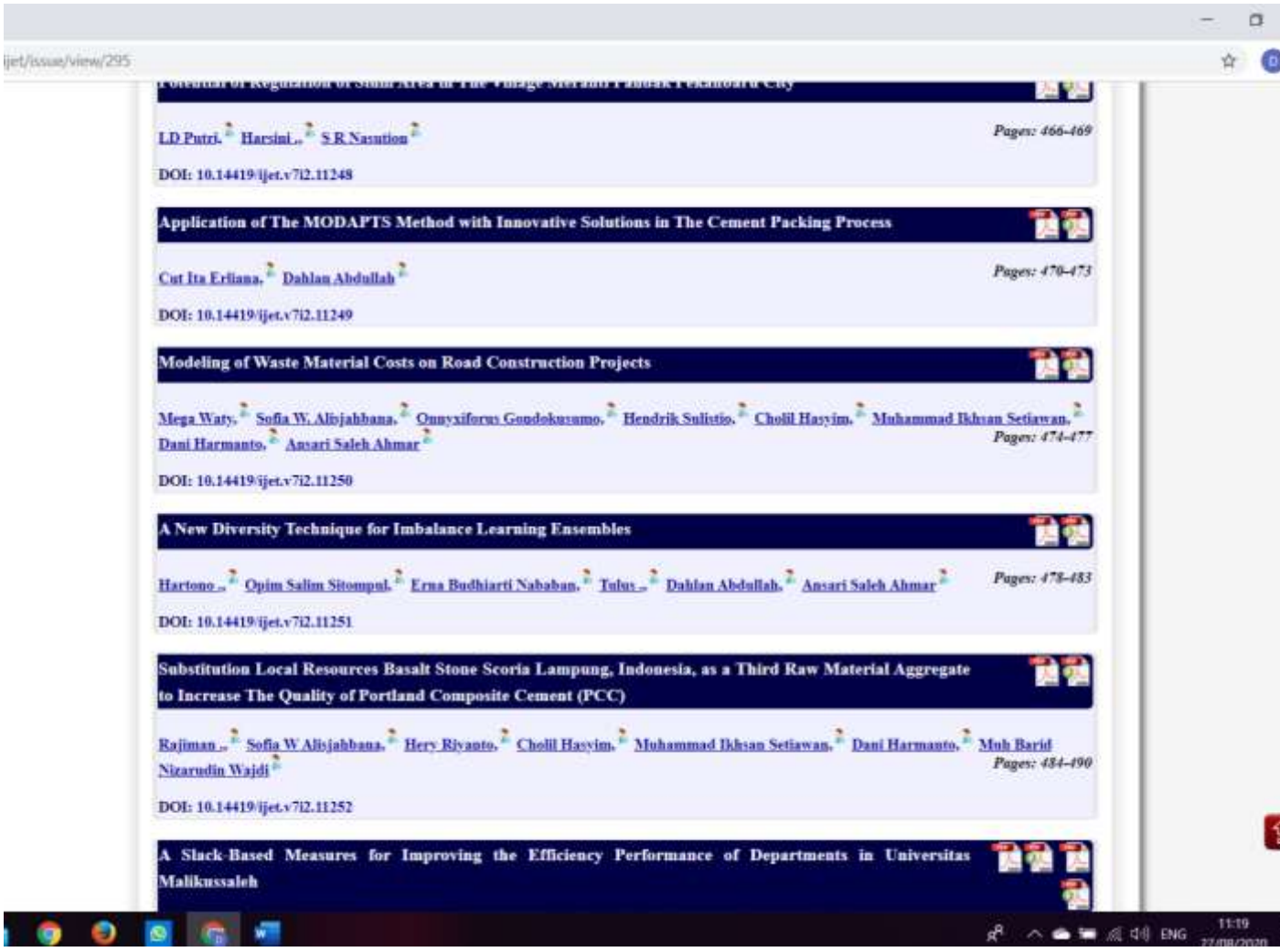

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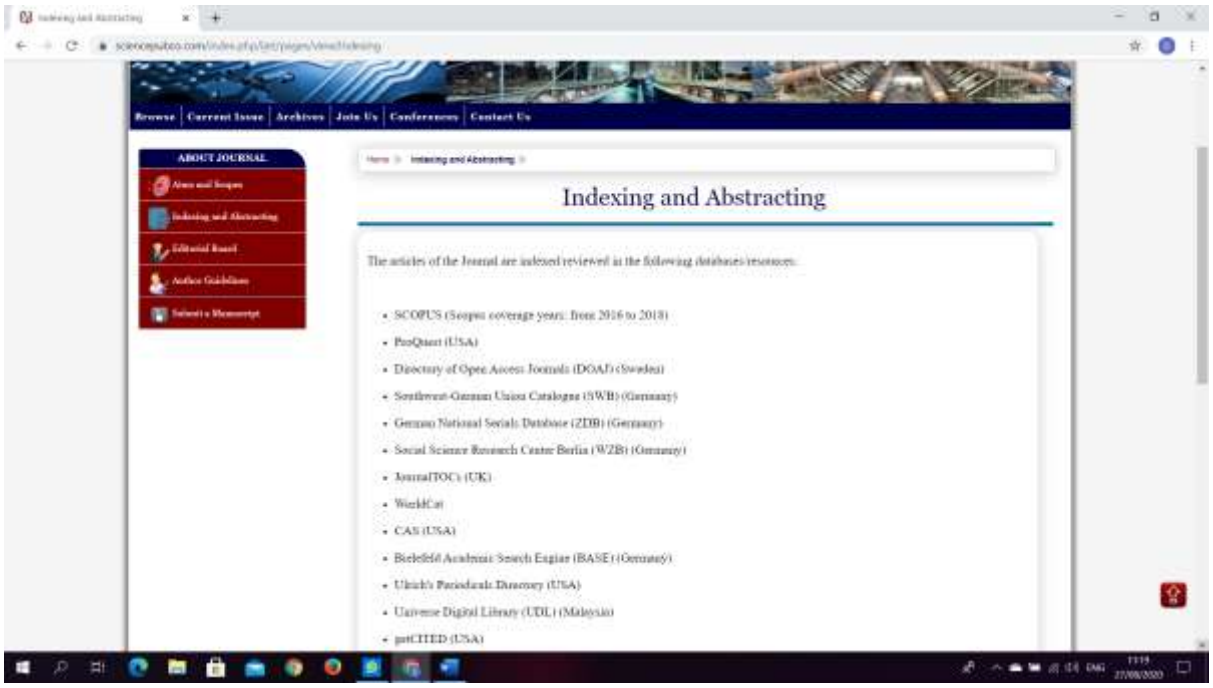

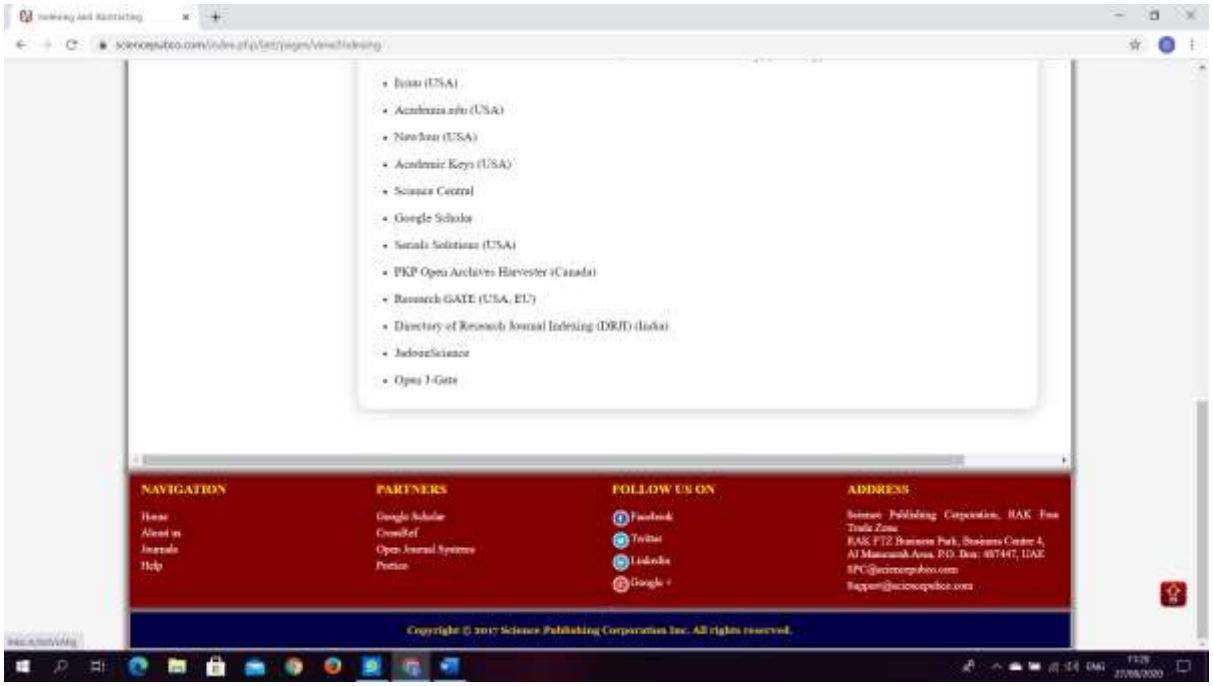
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Research paper

Modeling of Waste Material Costs on Road Construction Projects

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This Paper is based on a presentation given by the authors at "Workshop of KO2PI" held from 19 January 2018 to 20 January 2018 in Indonesia.

Abstract

Material waste is a term from the amount of waste material percentage and is one of the serious problems in the implementation of road construction project. The research objective is to calculate the average percentage of waste material in road construction projects and obtain waste material influencing profit and make a regression model of % material waste to % profit contractors. The data obtained are 158 projects in East and North Kalimantan divided into 51 road building projects and 107 road improvement projects. The percentage of waste material on road building project is B aggregate as the largest (26%) and ready mix concrete (5.3%) as the smallest. The percentage of waste material on road improvement project is B aggregate as the largest (24.2%) and ready mix concrete (6.14%) as the smallest. The influencing waste material on the road construction project is B aggregate, lean concrete and ready mix concrete with regression equation to determine the estimated % profit contractor as a function of % material waste is Y = 7.363 -0.032 X3 - 0.078 X4 - 0.066 X6. The influenced waste material on road improvement projects are cement, B aggregate, and Land Fill with the regression equation to determine the estimated % profit of contractor as a function of % material waste is Y = 8,702- 0,037 X4- 0,054 X5- 0,044 X7.

Keywords: *Construction, Contractor, Road, Regression, and Waste Management.*

1. Introduction

Waste in the construction field can be interpreted as a loss or a loss of material resources, time (with regard to labor and equipment) and capital, which is caused by activities that cost money, directly or indirectly, but does not add value to end product for users of construction services. Waste material is a term from the large percentage of waste material occurs and is one of the serious problems in the implementation of the road construction project. Material is one component with contribution of 40-60% of the project costs. Material waste on construction project does not only focus on waste material at the site of the project, but is also associated with a number of other activities such as the stages of work that is not required, repair and rework, schedule delays, poor material handling, the selection of construction methods, waiting time, equipment, movement of workers and construction can reach 63% of all waste construction in Canada resulted from road and bridges construction. In addition, United States concluded that the major contributor of waste is from the construction of roads and bridges by 123 million tons. In 2010 China is estimated to produce waste by 800 million tons/year. Effort to minimize construction waste materials will help increase the profits of contractors and reduce environmental impact. Measurement of waste is an effective way to assess the performance of the production system as generally allow improvement for potential areas and inefficiencies sources can be identified. Construction materials is an important component in determining the cost of a project, more than half of the project cost is absorbed by the material used. Material waste that occurs in the execution of construction is quite high and extremely difficult to measure systematically. At the implementation phase of construction material the use of waste materials in the field is frequently large that the effort to memimize waste material is necessary to be applied. Road construction project is one of the priority infrastructure projects in East and North Kalimantan, as the roads in East Kalimantan and North Kalimantan, as they are mainly subgrade and aggregate. There are two types of government project: (1) Road improvement project means there has been road, but the asphalt and surface layer have been eroded; (2) The road building project is the construction of a new road [1]-[10].

2. Experimental Details

Waste material is aclassic topic, yet in Indonesia this issue has not been widely discussed, especially in road construction projects. The absence of data regarding waste material road construction project in Indonesia is because waste discussed is mostly only on the construction building project. Formoso (2002) suggests that the largest waste in building projects is cement by 6.4% to 247.1% of 41 sampling sites. Ready mix concrete, concrete steel, bricks and ceramics are also on the list. The largest construction waste in building project is bricks (12.31%) and sand (11.39%) [9]-[10]. Problem Identification: (a) The study was conducted on a road project in East Kalimantan with the largest waste is cement, followed by sand, stone, land fill, and ready mix concrete. The study was conducted with direct research by analyzing what occurs in the field, in addition to questionnaires. The results of both questionnaire and field data is in similar percentage between 6-10%. Validation for causing factors on road project are also generated including design, procurement, implementation, resulting in causing factor including unclear drawing information, lack detailing drawing of design , supply exceeding the needs and supply that cannot be made in small quantities, bad weather and carelessness of workers in the field. The total cost of waste is 6.86%. The study was conducted from January 2015 to September 2015; (b) Recent research on road projects in the Ring Road 3 East Kalimantan shows that the largest waste is aggregate B, sand, A aggregate respectively by 20% followed by the rebars by 10% S Aggregate by 5%, ready mix concrete by 4 % and lean concrete by 1%. Total material of waste is 5.3% to the overall project value. Factors that cause road project include design, procurement, implementation, handling that produce causal factors including unclear design, Lack information design, supply material exceeding than the demand and supply material that cannot be made in small quantities, bad weather and not careful handling, emphasis on time, emphasis on cost. The research is conducted from October to December 2015. Primary data is data obtained directly in the field, this include Direct observations with interviews and discussions by directly asking about the percentage of material waste and total waste and contractors profit. Secondary data is real project data in the form of contractors report both hard copy and soft copy in fiscal year of 2014 until 2015 in East Kalimantan and North Borneo. Contractors report is in the form of daily reports, monthly reports, monthly certificates, and contractors' s contract. The researchers perform re-checking by using data from the existing reports to recalculate the percentage of waste material [9]-[10]. Multiple Linier Regression is virtually identical to a simple linear regression, the difference is that the independent variables is more than one. The general equation is [11]-[19]:

$Y = \alpha + \beta 1\ X1 + \beta 2\ X2 + ... + \beta n\ Xn.$

Y is dependent variable, and X is independent variables, α is a constant (intercept) and β is the regression coefficient of each independent variable [11-18]

Hypothesis of this study are:

$Y=\alpha - \beta 1\ X1 - \beta 2\ X2 - .... - \beta 9\ X9.$

Y= % Profit

X1 = Material waste of formwork has negative effect (-) to the profit of a project

X2 = Material waste rebar has negative effect (-) to the profit of a project

X3 = Material waste of ready mix concrete has negative effect (-) to the profit of a project

X4 = Material waste of B aggregate has negative effect (-) to the profit of a project

X5 = Material waste of land fill has negative effect (-) to the profit of a project

X6 = Material waste of lean concrete has negative effect (-) to the profit of a project

X7 = Material waste of cement has negative effect (-) to the profit of a project

X8 = Material waste of stone has negative effect (-) to the profit of a project

X9 = Material waste of sand has negative effect (-) to the profit of a project

3. Result and Discussion

This research obtains results from 158 road construction project as respondents, which consists of Roads construction and Road Improvement package. Based on these data, the researchers divided it into 51 Road Building Project and 107 Road Improvement Project.

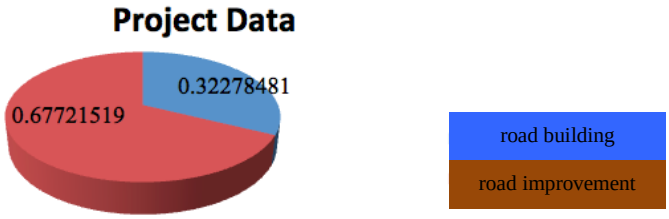

Fig.1: Package of Road Building and Road Improvement Project

Data Analysis of Waste Material Percentage, was performed to calculate the percentage of material waste from the sites, both Roads Improvement and Road Building Projects. Description of waste material is as follows: (1) Mean the highest percentage of waste material is aggregate B by 26.12%, and the lowest is ready mix concrete by 5.39%. Mean the percentage of profit from road construction project is 4.53% and average total cost of waste is 5.3%; (2) Median the largest percentage of waste material on aggregate B is 26.25% and the lowest is ready mix concrete by 5.75%. Median the percentage of the profit the road building project is 4.5% and total waste is 4.5%; (3) Modus the largest percentage of material waste is B aggregate by 26.5% and the lowest is ready mix concrete by 6%. Modus percentage of road construction profit that appears most frequently is 4.3% and total waste is 5.5%. Regression results with enter method indicates that Adjusted R Square (koeficient determination) indicates the coefficient determination is 0.870 as shown in Table 3. The results of Adjusted R Square 0.870 shows the strong influence from three waste material to profit projects, they are : aggregate B, lean concrete and ready mix concrete.

Model equations obtained is: Y = 7,363- 0,032 X3 - 0.078 X4 - 0.066 X6; Where: Y = % Profit; X3 = % Ready Mix Concrete Material Waste; X4 = % B Aggregate Material Waste; X6 = % Lean Concrete Material Waste

T Test, Test results exhibits that t is greater than t table in where t of formwork showed 9.648 greater than 1,833. Similarly with other waste materials

F Test, The test results showed that F table 99.018 > F table by 2.1 indicating that three materials, aggregate B, lean concrete and ready mix concrete greatly affects the profit

Road Regression Model Obtained Y = 7,363- 0,032 X3 - 0,078 X4 - 0,066 X6 ; Where: Y = % Profit; X3 = % Material Waste of Ready Mix Concrete; X4 = % Material Waste of B Aggregate; X6 = % Material Waste of Lean Concrete. Validation:

Y = 7,363- 0,032 X3 - 0,078 X4 - 0,066 X6

Y46 = 7,363 – 0,032x3,65 – 0,078x24,25 – 0,066x4,4 = 5,045

Y47 = 7,363 – 0,032x3,55 – 0,078x24 – 0,066x4,3 = 5,074

Y48 = 7,363 – 0,032x3,6 – 0,078x24,25 – 0,066x4,45 = 5,043

Validity of Data Road Building Project, Data validity of profit is obtained from the contractor by conducting interviews with the competent authorities, i.e the managing director or related parties who know about contractor's profit such as Site Manager. Maximum and Minimum Profit, Based on regression model:

Y = 7,363- 0,032 X3 - 0,078 X4 - 0,066 X6

The data is obtained in the range as follows:

$X3 = 3{,}5 \leq x \leq 6{,}85$

$X4 = 23{,}5 \leq x \leq 28{,}25$

$X6 = 4{,}5 \leq x \leq 7{,}5$

To arise the maximum profit it is necessary to obtain the minimum of waste material as in the above range. After obtaining regression model that has been tested in both validation and validity of the data, the model can be used for contractors in following auction. When contractors bid, they certainly pay attention in order to achieve maximum profit with minimum waste. Regarding limits (range) of waste material, it is expected that contractors can anticipate by producing minimum waste for increase maximum profit. To be achieve minimum waste, risk management at construction is necessary.

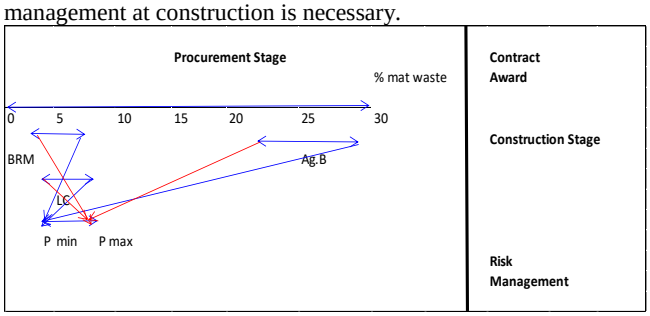

Fig. 2: Benefit Regression Model of Material Waste Road Building Project

Description of waste material is as follows: (1) Mean the highest percentage of waste material is a B aggregate by 24.12% and the lowest is ready mix concrete by 6.14%. Mean the percentage of profit on road improvement project is 6.16%, the total waste is 7,15%; (2) Median the largest percentage of waste material is B aggregate by 24% and the lowest is the ready mix concrete at 5.75%. Median of road improvement project profit percentage is 6.275% and total waste is 7.18%; (3) Modus the largest percentage of material waste is B aggregate by 23% and the lowest is ready mix concrete by 5%. Modus data of profit percentage for road improvement that frequently arises is 6%, total waste that occurs is 8%.

Enter method regression results show that that Adjusted R square (coefficient determination) indicates the coefficient of determination of 0.933. The results of Adjusted R Square is 0.933 indicating strong influence of the three material waste to profit projects of Cement, Aggregates B and Land. The model equations obtained is: Y = 8,702- 0,037 X4- 0,054 X5- 0,044 X7; Where: Y =% Profit X4 =% Waste Material B Aggregate, X5 =% Material Waste of Land Fill , X7 =% Waste Material Waste of Cement.

T Test, Test results of t are greater than t table by 1.833 where t B Aggregate showed 2,993 , greater than 1,833. Similarly with other waste materials, the detail is shown in

F Test, The test results table shows F is 461,037 > F table that is 1.97 then shows the waste material ie: cement, aggregates B and Land Fill affect profit happens.

Regression Model of Road Improvement, Then:

Y = 8,702 - 0,037 X4 - 0,054 X5 - 0,044 X7

The validation is:

Y101 = 8,8702 – 0,037x29,5 - 0,030x23 – 0,062x23 = 5,36

Y102 = 8,702 – 0,037x28 - 0,03x21,5 - 0,062x21 = 5,58

Y103 = 8,702 – 0,037x27 - 0,03x22 - 0,062x22= 5,55

Until the calculation of Y107 as shown in Table 16 and the results of the table shows that the model can be used. Data validity of profit from Road Improvement Project is obtained from the contractor by conducting interviews with the competent authorities, i.e the managing director or related parties who know about contractor's profit such as Site Manager. Maximum and Minimum Profit of Road Improvement Project, From the resulting model regression, the equation as follows:

Y = 8,702 - 0,037 X4 - 0,054 X5 - 0,044 X7

The data is at the range of:

X4= 18,5≤ x ≤ 29,5

X5= 10,75 ≤ x ≤ 23

X7= 11,5 ≤ x ≤ 23

To obtain the maximum profit it is necessary to obtain the minimum waste materials such as at range above the results. Benefit Regression Model of Road Improvement Project, After obtaining regression model that has been tested in both validation and validity of the data, the model can be used for contractors in following auction. When contractors bid, they certainly pay attention in order to achieve maximum profit with minimum waste. Regarding limits (range) of waste material, it is expected that contractors can anticipate by producing minimum waste for increase maximum profit. To be achieve minimum waste, risk management at construction is necessary.

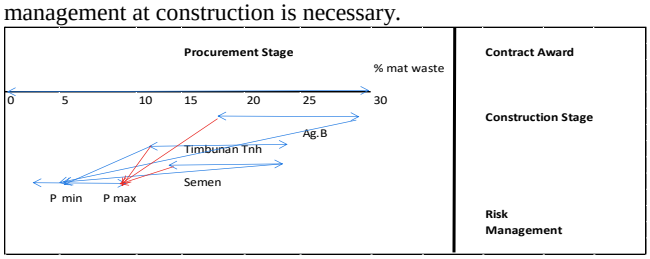

Fig. 3: Benefit Regression Model of Material Waste Road Improvement Project

4. Conclusion

The largest average percentage of waste material of road building project is B aggregate (26%) while the lowest is ready mix concrete (5.3%), from the largest to smallest is the B Aggregate, land fill, sand, stone, cement, formwork, rebar, lean concrete, ready mix concrete. The largest average percentage of waste material of road improvement project is B Aggregate (24.2%) and the lowest is ready mix concrete (6.14%) from the largest to smallest is the aggregate B, land fill, sand, stone, cement, formwork, rebar, lean concrete, ready mix concrete. Material waste affecting the road building project of 9 items of material waste is the B aggregate, lean concrete and ready mix concrete and the result is seen from the regression equation of Y = 7.363 - 0.032 X3 - 0.078 X4 - 0,066 X6, where: Y =% Profit, X3 =% material waste of Ready Mix Concrete, X4 =% material waste of B Aggregate, X6 =% material waste of Lean Concrete with Adjusted R square is 0.87. The waste material affecting road improvement project of 9 items material waste are cement, B aggregate, and soil deposits and the result seen from the regression equation Y = 8.702 - 0.037X4 - 0,054 X5 - 0,044 X7, where: Y =% Profit, X4 = % Material Waste of B Aggregate, X5 =% Material Waste of Land Fill, X7 =% Waste Material of Cement with adjusted R-square is 0.933.

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