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Cost Allocation Model In Construction Projects

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Abstract-Cost estimation is an important element in the overall cost management project, It is used to plan and control the resources, such as materials, labor, and equipment. In this case, the construction management has function to ensure the implementation of the construction project properly in order to achieve the goals of the project. Project planning urgently needs a precise and accurate method in analyzing the allocation of the proportion cost of the resources planned. It must be implemented in the beginning before start of the construction, therefore it is necessary to conduct a detail study of the factors related to the financial of the composition of resources such as labor, materials, and tools. Previous researches on cost allocation of construction project resources were carried out; Hermiati, Zahraie, B. and Tavakolan, M., Lin, K., Heon Jun, D. and El-Rayes. K. Hermiati. (2007) conducted a study about Modeling and Analysis of the wages of labor in the construction projects with the research objects of infrastructure development projects (building). Zahraie, B. and Tavakolan, M. (2009) examined *the Stochastic Time-Cost-Resource Utilization Optimization (TCRO) Using Nondominated Sorting Genetic Algorithm and Discrete Fuzzy Sets)*. Lin, K. (2011) has conducted research on Human Resource Allocation for Remote Project Construction. Heon Jun, D. and El-Rayes, K. (2011) conducted research on *Multi-objective Optimization of Resource Leveling and Allocation during Construction Scheduling*. Previous researches on resource variable of project construction carried out by Muzayanah, et al. Muzayanah, et al (2008) modeled the proportion of project construction resources. The conclusion was in the form of a mathematical model of the proportion of project resources, and the average use of construction project resources. The conclusion was mathematical proportion of project resources and the average of construction project resources in a simple building compared to non-simple building. The conclusion of the first year study was project construction cost that has four variables; Wibowo, et al (2014), consisted of the cost variable of human resources, building material, equipment, and others cost. The final conclusion of this study (Wibowo, et al, 2015) resulted in a statistical/ mathematical model and conceptual framework model of the decision making system on the cost allocation of construction project. Statistical/ Mathematical Model of Cost Allocation on Project Construction in general "Yn = Pn + Qn + Rn + Sn", which Yn shows the variable of Construction Costs. P Variable indicates the variable cost of Human Resources, Q shows Variable Cost of Building Materials, R shows the variable cost of equipment, and S indicates Other Costs Variable. Each of these variables is the model formula of Other Costs. The formulation of the model variables P, Q, R, and S depends on the value of Y.

1. Introduction

Estimated cost is an important element in terms of the overall project cost management, both in the planning and control of resources, such as materials, labor, and equipment. In this case, the construction management has the function to properly ensure the implementation of the project (construction) in order to achieve the employment goals of the project, namely timeliness, cost, and quality. In addition, the proportion of the cost for the resource needs is the largest allocation for a construction project, so it can be said that the resource is a determinant in the efficiency of construction project financing. Inaccuracy of calculation would cause a problem in financing the project, so it will be difficult to achieve the efficiency projects.

One of the recent strategic issues in the world of construction is competition on price quotations that are very strict in job offers, so it appears that a lot of the winning bidder is the contractor offering prices below the standard. Project planners really need a precise and accurate method in analyzing the allocation of the cost of the proportion of resources that are already planned. It must be implemented in the beginning of the planning, before the construction begins. Therefore, job offers can be done at a reasonable price. Unfortunately, until now there has been no research results that indicate resource allocation costs of construction projects that can be used as reference or as control for the calculation of the project cost planning.

2. Planning Project Costs

Project planning really needs a precise and accurate method in analyzing the allocation of the cost of the proportion of resources that are already planned. It must be implemented in the beginning of the planning, before the construction begins, so it is necessary to do a detailed study on the financial reasons, related to the composition of resources such as labor, materials, and equipment.

Cost planning of construction projects plays an important role in the management of the project cost (Trigunarsyah, 2005; Soeharto, 1995). In the first stage, the conceptual stage is used to determine how much it cost to build the project or the Investment (Soeharto, 1995). Furthermore, cost estimations have function with a very broad spectrum, namely the planning and control of resources, such as materials, labor, and equipment (Darmawan, 2006; fahirah, et al, 2005). Although it has the same function, but the emphasis is different for each organization participating in the project (Darmawan, 2006). To the owner, numbers shows amount of cost estimation that will be one of the references to determine the feasibility of an investment. For contractor, financial profit earned depends on the ability to estimate the cost, while for consultant, this number is proposed to the owner as best cost proposal for various uses based on the project development and to particular levels, credibility related to truth and accuracy of the proposed amount (Santoso, 1999).

In a broad context, construction management has the function to properly ensure the implementation of the project (construction) in order to achieve the performance targets of the project, namely timeliness, cost and quality. Because the performance targets are actually the result of estimation, it must be recognized that the correspondence between the performance targets with actual results achieved cannot be ensured (Santoso, 1999). The element inputs of the construction project include men (labor), money (expense), methods (methods), machines (equipment), materials (materials) and market (the market), all these elements need to be arranged so that the proportion of elements that become needs in the construction project can be precise in its use and the project may run efficiently. The accuracy of calculation is necessary for the requirements planning. Inaccuracy of the calculations will lead to swelling costs so the project's efficiency is difficult to achieve (Hermiati, 2007).

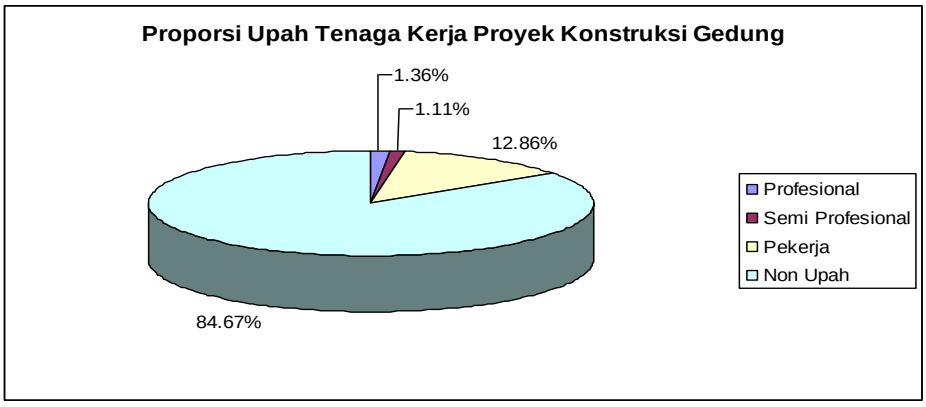
As pointed out in the background, One of the recent strategic issues in the world of construction is competition on price quotations are very strict in job offers, so it appears a lot of the winning bidder is the contractor offering prices below the standard. This will greatly affect the implementation of the project work, among others, the possibility of a reduction in the quality or quantity of work, which may have an impact on construction failures.

The emergence of offers below the price is predicted due to several reasons, among other positive conditions for intelligence of contractors in planning an effective implementation strategy, or because of the availability of equipment and materials, better

and ready. Negative possibilities of the low offer could be due to calculation error, either due to lack of rigor or less known as good allocation of resources costs. If allowed to continue these adverse conditions, it is very possible that bankruptcy will continue contracting construction services, and even more. This will also impact to the reduction of labor supply, increased unemployment, and the reduction of state revenues from the construction sector.

3. Resource Allocation Cost Of Construction Projects

Hermiati (2007) conducted a study on Modeling and Analysis of Labor Wage in the Construction Project with infrastructure development projects (building) as the object of resarch aimed at knowing the proportion of labor income construction. In the study, factors that are reviewed include the value of the contract, the duration of the project, as well as the number of floors of the building. The results showed that the proportion of labor costs on the building project was 15.33%, while the rest are for non-wage, more details as below Figure 2.1:



Source : Hermiati,2007

Figure 1. The proportion of Wages Labor Building Construction Projects

Zahraie, B. and Tavakolan, M. (2009) studied the Stochastic Optimization of Time-Cost-of Resource Using *Genetic Algorithm Sort Non-dominant and Discrete Fuzzy Set (Stochastic Time-Cost-Resource Utilization Optimization (TCRO) Using Nondominated Sorting Genetic Algorithm and Discrete fuzzy Sets*). The study aimed to hold a model development *Time-Cost-Optimization (TCO) into the Time-Cost-Resource Utilization Optimization (TCRO)* with a case study on two (2) construction projects. Zahraie, B. and Tavakolan, M. stated that the construction project, the cost and duration of the activity may change due to uncertainly different variables such as weather, availability of resources, and others. Strategy and equitable allocation of resources can affect the total time and cost of the project. Two concepts of time-cost of financing and the distribution and allocation of resources have been included in the multi-objective stochastic optimization model that minimizes the total project time, cost and resource interests.

Lin, K. (2011) has conducted research on the Allocation of Human Resources for Foreign Project (Human Resource Allocation for Remote Construction Projects) on some construction projects and case studies in three (3) foreign construction projects, with the aim is to Getting the Model Decision for Resource Allocation Human Resources in Foreign Construction Projects

Lin, K. (2011) proposed a model of decision-making for the allocation of human resources in foreign construction projects to estimate the "total cost of the project," which is the sum of the total cost of expansion, estimated project losses, and direct construction costs. Furthermore, the model result in these studies was tested with the case studies on three foreign construction projects. The trial results showed that the project staff trained (regular) was able to reduce managerial weaknesses and mitigate the loss of the project, compared to the local project staff.

Heon Jun, D. and El-Rayes, K. (2011) conducted research on the Multi-Objective Optimization of Equity and Resource Allocation for Construction Scheduling (*Multi-objective Optimization of Resource Leveling and Allocation during Construction Scheduling*). The study was conducted on some construction projects with the aim to obtain multi-purpose model that combines the maximization of resource utilization efficiency and the minimization of the duration of the project.

Heon Jun, D. and El-Rayes, K. (2011) states that it is necessary for the development of a new model of multi-objective optimization, which is able to measure and minimize fluctuations of unwanted resources to maximize the efficiency of resource utilization and minimize the duration of the project which impacts on cost minimization, as well to comply with all of predecessor relationships (precedence) and resource availability constraints. The model incorporates three main modules: (1) the beginning module (start-up) that calculates the lower and upper bounds for variable decision model, (2) scheduling module which generates a schedule of practical and evaluate their performance, and (3) genetic algorithm multi-objective module which can find and identify the optimal schedule.

4. Variable Of Construction Project Resources

Muzayanah, et al (2008) modeled the proportion of resource construction projects, which is a special object that is used in building construction projects are divided into simple building and non-building simple. The study aimed to obtain a model of the proportion of resources on construction projects and determined the level of influence of several variables to resources. In this study the types of resources are divided into three groups, namely: material (Y1), human (Y2) and equipment (Y3). The proportion of these resources is affected by several variables: the value of the project (X1), duration (X2), variations in the number of floors of the building (X3), and the building area (X4). Samples of construction projects in the study are categorized by the building project complexity, functionality, and the type of technology used. Based on this, building construction project is divided into two, namely simple and non-simple building.

From the analysis Muzayanah, et al (2008) above, it can be concluded that some of the issues related to the proportion of the mathematical model of project resources, and the average use of resources in construction projects, in simple buildings than in non-simple building is as follows:

a. mathematical model that can be used in simple buildings are:
   Type Linear Equations resources
   Material Y1 = 0,641+ 6,04E-012x1- 0,001x2+0,008x3+4.79E-005x4
   Human Y2 = 0,203-1,76E-011x1+0,001x2+0,021x3-3.52E-005x4
   Equipment Y3 = 0,156+1.16E-011x1+0,000x2-0,029x3-1.27E-005x4
b. mathematical model that can be used in non - simple buildings are:
   Type Linear Equations resources
   Material y1 = 0,745+3.38E-012x1 + 0,0001x2-0,012x3
   Human y2 = 0,580-1,05E-012x1+0,0001x2+0,01x3
   Equipment y3 = 0,192-2,17E-012x1-5,08E-005x2+0,001x3

c. The average use of resources construction projects, in simple buildings than in non-simple building does not have a big difference, but it can be identified that the use proportion of the cost for human resources in simple buildings is higher when compared to non-simple building. Conversely, the proportion of resource use equipment in a non-simple building is actually higher. This is possible because simple buildings also use simple technology, so it requires a lot of human resources and less use of equipment, and vice versa.

5. Types of Costs Allocation Variables Of Construction Projects

Research on the allocation of costs on construction projects by Wibowo, et al (2014) concluded that the construction cost of a project has four variables:

a. Costs Variable of Human Resources consisting of Project Management Team Costs, Labor Costs for contract work and the daily cost of manpower for the work which is difficult to do.
b. Costs Variable of Building Materials consists of quarry materials (natural materials), general manufacturer materials (factory mass product) and Materials manufacturer for special order.
c. Costs Variable of Equipment consists of Office Equipment cost, and Heavy and Light Equipment Costs.
d. Other Costs Variable consists of insurance, taxes cost, tactical / unexpected cost, social, banquet cost and laboratory tests cost.

6. Cost Allocation Model In The Proportion Of Construction Projects

Our results split the cost objects based on the type of project. There are 8 types of projects studied, the simple buildings, buildings, roads, bridges, dams, irrigation canals, harbors and airports.

Table 1. Statistical/ Mathematical Cost Allocation Proportion Model on Construction Projects

Kinds Of Project & Project Code	**Statistic / Matematics Model**			
	General Mode : Yn = Pn + Qn + Rn + Sn M0del Of Each Sub Variable:			
	P	**Q**	**R**	**S**
Simple Building (Y1)	P1= 0,31y1	Q1=0,52y1	R1=0,06y1	S1=0,11y1
Complex Building (Y2)	P2= 0,32y2	Q2=0,48y2	R2=0,09y2	S2=0,11y2
Road (Y3)	P3= 0,21y3	Q3=0,56y3	R3=0,12y3	S3=0,11y3
Bridge (Y4)	P4= 0,26y4	Q4=0,53y4	R4=0,09y4	S4=0,12y4
Dam (Y5)	P5= 0,26y5	Q5=0,52y5	R5=0,11y5	S5=0,11y5
Irrigation (Y6)	P6= 0,29y6	Q6=0,54y6	R6=0,06y6	S6=0,11y6
Harbour (Y7)	P7= 0,23y7	Q7=0,56y7	R7=0,13y7	S7=0,08y7
Airport (Y8)	P8= 0,23y8	Q8=0,50y8	R8=0,16y8	S8=0,11y8
Note : Y = Variable Of Cunstruction Cost P = Variable Of Human Resource Cost Q = Variable Of Material Cost R = Variable Of Equipment Cost S = Variable Of Other Cost				

7. Conclussion

Cost allocation Proportion Model on construction projects is based on the basic principles of the model and the proportion of allocation of costs on construction projects. The basic principle Construction costs model of a project has four variables (Wibowo et al, 2014):

a. Costs Variable of Human Resources consisting of Project Management Team Costs, Labor Costs for contract work and the daily cost of manpower for the work which is difficult to do.
b. Costs Variable of Building Materials consists of quarry materials (natural materials), general manufacturer materials (factory mass product) and Materials manufacturer for special order.
c. Costs Variable of Equipment consists of Office Equipment cost, and Heavy and Light Equipment Costs.
d. Other Costs Variable consists of insurance, taxes cost, tactical / unexpected cost, social, banquet cost and laboratory tests cost.

Statistical/ Mathematical Cost Allocation Proportion Model on Construction Projects in general "Yn = Pn + Qn + Rn + Sn", which Yn shows the variable of Construction Costs. P Variable indicates the variable cost of Human Resources, Q shows Cost Variable of Building Materials, R shows the cost variable of equipment, and S indicates Other Costs Variable. Each of these variables is the model formula of Other Costs. The formulation of the model variables P, Q, R, and S depends on the value of Y.