LIFE CYCLE COSTING OF ROAD ASSETS IN DISASTER ZONE
(CASE: ALAI – BY PASS ROADS, PADANG-INDONESIA)

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ABSTRACT

The output of current road preservation program can't compensate for the road damage. This condition was caused the road construction just oriented initial costs alone without considering the costs incurred in the future and shorter design life. Increased efficiency should be done by minimizing the use of available resources such as rehabilitation cost in life cycle, or cost average in the medium term. Whereas increased effectiveness through improved quality, enhanced performance and extended design life. Life cycle costing approach is the solution to produce the optimal cost in the management of road infrastructure.

Variable Life cycle costinging is obtained through interviews with expert who have classification at least 5 years experience related to road infrastructure. Life cycle costing model in this study using the present value method. Validation techniques used in the mathematical model is a parameter variability-sensitivity analysis, by changing the values of input and internal parameters of a model to determine its effect on the behavior of the model and the output. In this research conducted changing on the value of interest rate and the analysis period.

Life cycle costing variables obtained through expert interviews are planning costs, construction costs, routine maintenance cost, rehabilitation costs, reconstruction cost, vehicle operating cost (VOC) and user delay cost. Based on the calculations at the model development stage, pavement design alternative chosen is flexible pavement with 20 years design life. Interest rate and analysis period are not sensitve to decision.

KEY WORDS: Efficiency, Effective, Present Value, Life Cycle Costing

1. INTRODUCTION

Road infarastructure has an important role and influence on a country's economic growth. Fixed asset like road Infarastructure is the result of capital expenditure in provide public services by the government. To add fixed asset, the government allocates funds in the capital budget. Capital budget is expenditure that has benefits more than one year with consequence it will cause increased a routine expenditure as maintenance budget. Allocation of capital budget related to long-term financial planning, especially funding for the maintenance of fixed asset that resulted from capital budget. Maintenance expenditure aims to keep asset in order to remain in good condition, so it can support provision of services that have been determined based on the estimated economic useful life (Abdullah & Halim, 2006).

According to Abdullah & Halim (2006) which refers to Kamensky (1984) who conducted a study of the cities which be members of the National League of Cities, found that 57% of cities in the United States do not consider maintenance and repair cost to the expected life of the project. According to him, public managers need to understand about total cost of capital spending, not just spending on construction and procurement. According to Abdullah & Halim (2006) which refers to Thomassen (1990) also provide an important record for this capital budgeting. He stated that at least half of the state which reported items of

capital expenditure and non-capital expenditure separately failed to combine budget to evaluate simultaneously and comparative for both expenditures item.

In the simpler scope, capital budget is an procurement costs whereas maintenance budget is an operational and maintenance costs of assets. Based on asset management concept, the costs are an important component of asset planning. Asset management decisions are part of the overall framework of decision-making in an organization. Asset management approach as "whole of life" show that the importance to understand the phases of asset life cycle and accompanying costs.

Research on road infrastructure by Patterson & Harahap (2010) with the Australian Government concluded that national authority should increase the efficiency and effectiveness of road preservation program. Preservation is the maintenance, rehabilitation and reconstruction of roads. Costs required for this activity is called as preservation fund. Allocation of resources for road preservation program Rp.200 million/km/year or $20.000/km/year. The output shows that the program can not compensate for the damage level which is high enough. Minimizing the use of available resources such as repairs cost in life cycle, or the average cost of medium-term can increase efficiency. Effectiveness can be increased through improved quality, performance and extended design life. This condition caused by road construction is only oriented to initial costs without considering the costs incurred in the future and short design life.

Funding is a problem in road maintenance at many developing countries, included Indonesia. So road maintenance activities is not optimal. The government as agency not only element in the road infrastructure system. Policy in the management of road infrastructure assets must also consider the road users. According to the Asian Development Bank (2003), each additional $1 issued by developing countries for road maintenance, it will save road user cost of $3. The opposite also occurs if the maintenance is not done well. Poor road conditions will make the cost of road users increase. The research of Richard Robinson et al. (1998) says that increasing ruggedness of 2.5 m/km to 4.0 m/km would increase vehicle operating costs about 15% and if increased of ruggedness up to 10 m/km, vehicle operating costs would increase to 50% (Center for Research and Development of Transportation Infrastructure, 2005). So the expenditure level of road infrastructure affects to the cost of road users.

Implementation of Life cycle costings concept in road infrastructure management is a solution of these problems. Through this concept, we can estimate maintenance costs in next years, and the road user costs of each alternative. Therefore, the Life cycle costing approach can produce the optimum cost in manage of road infrastructure asset.

Life cycle costings concept in road asset management system can help in make effective decision at initial stages in asset planning. So the function of road infarastructure to increase competitiveness and sustain economic growth can be optimal.

2. RESULT AND DISCUSSION

2.1. Problem Definition

There are many models developed to calculate Life cycle costings. Each model is affected by different parameters. Based on these conditions, designed a Life cycle costing model of road infrastructure in Padang city exactly and accordance with the conditions of the system is being observed.

2.2 Identify Life cycle costing Variables

To obtain Life cycle costing variables that suit with the system conditions, so conducted interview with experts who have classification at least 5 years experience related to road infrastructure. Experts in this research are :

1. Unit work of Implementation National Road West Sumatra
2. Unit work Staff of Planning and Supervision National Road West Sumatra
3. Staff of Department of Road Infrastructure, Layout and Residential of West Sumatra
4. Head Division of Bina Marga of Department Public Work Padang City
5. Head Section of road Department Public Work Padang City
6. Akademics
7. Consultant

Results of interview with experts about Life cycle costing variables can be shown in Table 1.

Tabel 1. Recapitulation Life cycle costing Variables Based on the Results of Interview.

Life cycle costing Variables	Experts						
	1	2	3	4	5	6	7
Planning Cost	√	√	√	√	√	√	√
Construction Cost	√	√	√	√	√	√	√
Routine Maint. Cost	√	√	√	√	√	√	√
Rehabilitation Cost	√	√	√	√	√	√	√
Reconstruction Cost	√	√	√	√	√	√	√
User Delay Cost	√	√	√	√	√	-	-
Vehicle Operating Cost	√	√	√	√	√	√	-
Accident Cost	-	-	√	-	√	-	-
Salvage Value	√	√	√	√	√	√	√
Vulnerability Cost	-	√	-	-	-	-	-

Source: Results of Expert Interviews

Based on results of interviews with experts are obtained Life cycle costing variables of road infrastructure asset, as below:

a. Planning Cost
   Represents the cost in plan the construction design of an investment.
b. Construction Cost
   All costs which incurred in order to realize the physical form of the project in accordance with the detailed engineering design that included in the documents contract specifically drawing plans and technical specifications, which decomposes in the form of materials, equipment and methods of implementation and budget plan.
c. Routine Maintenance Cost
   It is a cost of the activity care and repair the damage that occurred to the road sections with steady service conditions.
d. Rehabilitation Cost
   Represent the costs of activities in handle preventing extensive damage and any damage that is not considered in the design that resulted decline in condition of road with a light damage condition, in order to decrease the stability condition can be returned to stable condition according to plan.
e. Reconstruction Cost
   The cost of increasing structure like handling activities cost to improve the road capability which in poor condition so the road has a stable condition back in accordance with the specified design life.
f. User Delay Cost
   Represents the costs incurred by road users such as loss of time (delay) due to construction, rehabilitation, or reconstruction of roads activity (workzone).
g. Vehicle Operating Cost
   Represents of the costs incurred during the vehicle moves through the streets (under normal conditions), and increased due to construction, rehabilitation, or reconstruction of roads activity (workzone).
h. Salvage Value
   Represents the value of an alternative investment at the end of the analysis period.

The accident cost variable is a part of the road users cost. Based on the results this variable is not relevant variable in application of Life cycle costing concept of. For example, in determine pavement design to be used, the value of accident cost would be very difficult to predict. Vehicle operating cost and user delay cost is considered to represent the road users cost.

Vulnerability cost variable in Life cycle costing of bridges associated with the earthquake is not accounted in the Life cycle costing of road infrastructure assets. Based on interview the earthquakes should not affect to pavement design. It means that in initial stages of plan the road pavement design, there is no consideration whether the area is prone to earthquakes or not.

2.3 Model Formulation

Variables that have been identified at previous stage is converted into a mathematical form.
The following is equation of present value method (PV) :

$$P = \frac{F}{(1+i)^n} \qquad (1)$$

Description :
P = Present Worth
F = Future Worth
i = Interest
n = Period

The following is mathematical models of Life cycle costing road infrastructure in this research, based on the stages in the decision-making process:

$$1.\ LCC_k = PV\,(AC_k) + PV\,(UC_k) \qquad (2)$$
$$= PV(E_k+C_k+R_k+P_k+N_k-S_k) + PV\,(V_k+D_k)$$

Description :
PV = Present Value

AC_k = Agency Cost alt.-k
UC_k = User Cost alt. ke-k
E_k = Planning Cost alt.ke-k
C_k = Constructial Cost alt. -k
R_k = Routine Maintenance Cost alt.-k
P_k = Rehabilitation Cost alt.-k
N_k = Reconstruction Cost alt.-k
S_k = Salvage Value alt.-k
V_k = Vehicle Operating Cost alt.-k
D_k = User Delay Cost alt.-k

2. Objective Function

$$\text{minimum} \quad z = \sum_{k=1}^{y} LCC_k X_k$$

3. Constraint

$$X_k = \begin{cases} 0 & \text{if alternatif -k rejected} \\ 1 & \text{if alternatif -k accepted} \end{cases}$$

Before entering into the next stage, a mathematical model that has been developed then verified, the goal is to see the model's ability to solve problems.

2.4 Analysis and Model Solution

The model has been developed then tested. Data used in calculate Life cycle costings are construction data on Alai -By.pass Padang. The calculation is performed by comparing the Life cycle costing of flexible pavement 10 years design life (alternative 1) which is the current standard of National authority, with flexible pavement 20 years design life (alternative 2) which is an international design standard. Recapitulation of management both alternatif with analysis period equal to 25 years, shown below :

Tabel 2. Recapitulation of Management Alternatif 1

Year to-	Activity
0	Planning
0	Construction
1-4	Routine Maintenance
5	Rehabilitation
6-9	Routine Maintenance
10	Reconstruction
11-14	Routine Maintenance
15	Rehabilitation
16-19	Routine Maintenance
20	Reconstruction
21-24	Routine Maintenance
25	Rehabilitation

Tabel 3. Recapitulation of Management Alternatif 2

Year to-	Activity
0	Planning
0	Construction
1-9	Routine Maintenance
10	Rehabilitation
11-19	Routine Maintenance
20	Reconstruction
21-25	Routine Maintenance

The results of the calculation by using present value method :

Tabel 4. Recapitulation of Life cycle costing

Variable	Alternative1	Alternative2
Agency Cost	Rp.21,034,826,293	Rp.19,913,418,073
User Cost	Rp.412,562,565	Rp.312,932,416
Total	Rp.21,447,428,858	Rp.20,244,350,488

Based on calculations, obtained the smallest value of Life cycle costing at alternative 2, it is flexible pavement with 20 years design life.

Validation technique is used to the mathematical model is parameter variability-sensitivity analysis, by change the values of input and internal parameters of a model to determine their effect to behavior model and the resulting output. In this research do by change the value of interest rate and the period of analysis.

Sensitivity analysis performed on interest rate factor by changing values be +40%, +20%, -20%, -40% of 4.28%.

Recapitulation of sensitivity analysis to changes in interest rate can be seen on Tabel 3.

Tabel 5. Recapitulation of Sensitivity Analysis to Changes in Iinterest Rate

Interest Rate	Alternative1	Alternative2
2.57%	Rp.23,592,433,801	Rp.20,957,103,963
3.42%	Rp.22,448,660,514	Rp.20,586,549,759
4.28%	Rp.21,447,428,858	Rp.20,244,350,488
5.14%	Rp.20,568,167,677	Rp.19,930,068,719
5.99%	Rp.19,793,602,883	Rp.19,642,632,606

Sensitivity analysis to analysis period factor is done by changing the first analysis period is 25 years be 18 years, 21 years, 29 years, 34 years and 39 years.

The following is recapitulation of sensitivity analysis of changes in analysis period.

Tabel 6. Recapitulation of sensitivity analysis to changes in analysis period

Analysis Period	Alternative1	Alternative2
18	Rp.19,180,252,308	Rp.18,240,169,015
21	Rp.19,536,458,341	Rp.15,835,793,680
25	Rp.21,447,428,858	Rp.20,244,350,488
29	Rp.22,171,392,469	Rp.20,942,135,538
34	Rp.23,018,985,561	Rp.22,348,004,557
39	Rp.24,255,954,597	Rp.22,798,529,792

The results of sensitivity analysis in present value method is interest rate and analysis period factor does not affect to change in the decision. It can be concluded that decision in determine kind of flexible pavement with 10 years and 20 years design life are not sensitive to interest rate and analysis period factors.

Sensitivity analysis of the analysis period also aims to see changes in the salvage value. The following is recapitulation of salvage value of flexible pavement design alternatives:

Tabel 7. Recapitulation sensitivity analysis of analysis periode to salvage value

Analysis Period	Salvage Value Alternative1	Salvage Value Alternative2
18	Rp.423,276,448	Rp.766,223,323
21	Rp.1,679,707,072	Rp. 5,985,000,000
25	Rp.789,145,266	Rp.1,657,205,059
29	Rp.133,469,754	Rp.1,027,717,109
34	Rp.649,424,994	Rp.454,597,496
39	Rp.87,775,363	Rp.61,442,754

3. CONCLUSION

1. Life cycle costing variables obtained through expert interviews are planning costs, construction costs, routine maintenance cost, rehabilitation costs, reconstruction cost, vehicle operating cost (VOC) and user delay cost.
2. Based on the calculations at the model development stage, pavement design alternative chosen is flexible pavement with 20 years design life. Interest rate and analysis period are not sensitve to decision.

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