COMPUTER ASSISTED LIFE CYCLE COSTING OF ROAD ASSETS FOR DISASTER ZONE IN PADANG INDONESIA

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ABSTRACT

Efficiency and effectiveness of current road preservation program should be improved. Increased efficiency can be done in road preservation program by minimizing the use of available resources such as rehabilitation cost in life cycle, or cost average in the medium term. Whereas increased effectiveness can be obtained through improved quality, performance and extended design life. Current road preservation can't compensate for the road damage because road construction just oriented to initial costs such as construction cost without considering the future costs and shorter design life. Life cycle costing approach can solve this problem and produce optimal cost in road infrastructure management.

Variable Life cycle costing 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 capitalized worth method. Life cycle costing is calculated by manual and computational model.

Computational model of Life cycle costing can be used to calculate Life cycle costing with capitalized worth method. Result of Life cycle costing calculation both manual and computational model generate the same value.

KEY WORDS: Life Cycle Costing, Computer Assisted, Capitalized Worth

1. INTRODUCTION

Infrastructure asset is a government's investments which does not give income. Consequence of existence this asset is operational and maintenance burden in future for government. Indonesian Government Regulation No. 24 of 2005 in 14th paragraph, stated that :

"The government has invested large amounts of funds in assets that do not directly produce income for government, such as office buildings, bridges, roads, parks, and reservation areas. Most of the assets have a long useful life so they need the adequate program of maintenance and rehabilitation to keep their benefits that want to be achieved. So the function of the assets for the government differently for commercial organizations. Most of the assets do not produce direct income for the government, and even cause the government's commitment to maintain them in the future ".

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) in collaboration with the Australian Government concluded that Bina Marga 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 infrastructure asset management can help in make effective decision at initial stages in asset planning while providing a good quality of transportation services.

2. RESULT AND DISSCUSSION

There are many models have been 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 exactly and accordance with the conditions of the system is being observed. Model development aims to produce new models that has more capabilities in several aspects.

2.1 Life cycle costing Variables

The first step is identify variables that fit to the characteristics of the systems by 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

The results of interview with experts about Life cycle costing variables shown in Table 1.

Tabel 1. Recapitulation of 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	√	√	√	√	√	√	√
Vulneribility Cost	-	√	-	-	-	-	-

Source: Results of Expert Interview

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.

2.2 Model Formulation

Life cycle costing model on previous research, using present value (PV) and net present value (NPV) economic analysis method in its calculations. Whereas in this research Life cycle costing calculation using capitalized worth (CW). The reason for use of capitalized worth method (CW) on Life cycle costing calculation is:

1. Road infrastructure asset has perpetual useful life. Because of this characteristic, the approach of capitalized worth method that can change the analysis period into infinity (∞) judged appropriate. So this method can help the comparison of alternative when looping assumptions difficult to do.

2. Implementation net present value (NPV) method was considered inappropriately used in the calculate of Life cycle costings because road infrastructure asset is generally non-profit asset except toll road. Whereas net present value method is the result of net (profit) of an investment in present value.

The following is equation of capitalized worth method (CW) :

$$CW = A\left[\lim_{n \to \infty} \frac{(1+i)^n - 1}{i(1+i)^n}\right] \quad (1)$$

$$= A\,(1/i)$$

Description :

i = Interest

n = Period

A = Annual Payment

Variables that have been identified in the previous stage is converted into a mathematical form. The following is mathematical models of Life cycle costing road infrastructure in this research, based on the stages in the decision-making process:

1. $LCC_k = CW\,(AC_k) + CW\,(UC_k)$ (2)

$= CW(E_k+C_k+R_k+P_k+N_k-S_k) + CW(V_k+D_k)$

Description :

CW = *Capitalized Worth*

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 Maint.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

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

2.3 COMPUTATIONAL MODEL

Applying this research in the form of information system will be more accurate and faster in the calculation process. So the decision-making process will be more efficient in terms of time.

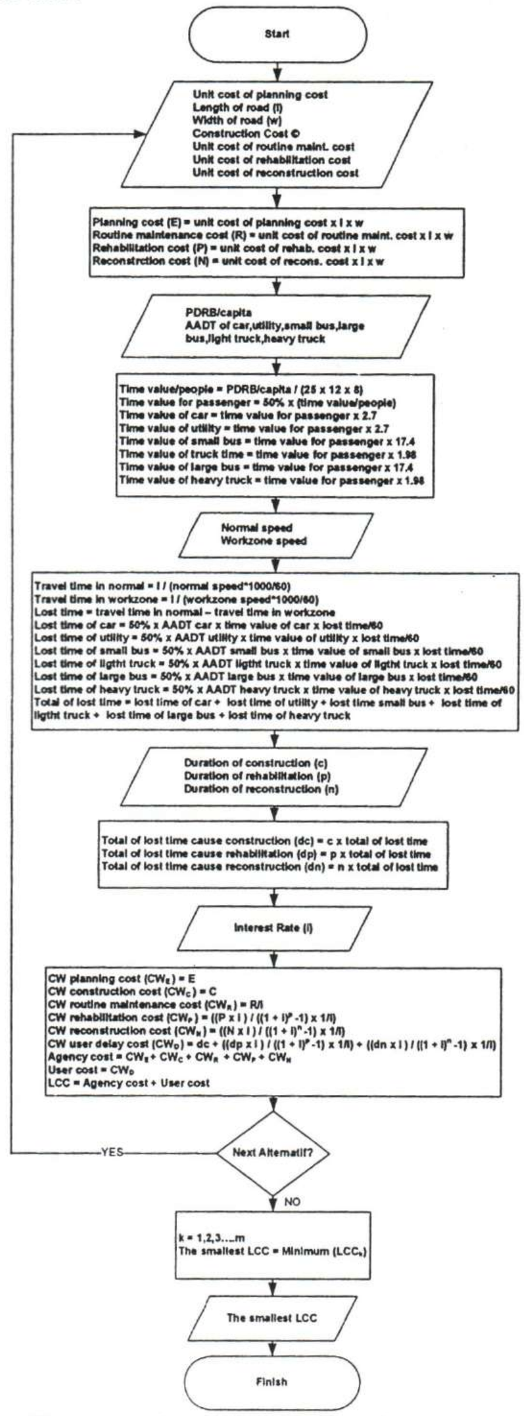

Figure 1. Flowchart of Life cycle costing Calculation

User interface of Life cycle costing computational model can be seen on Figure 2.

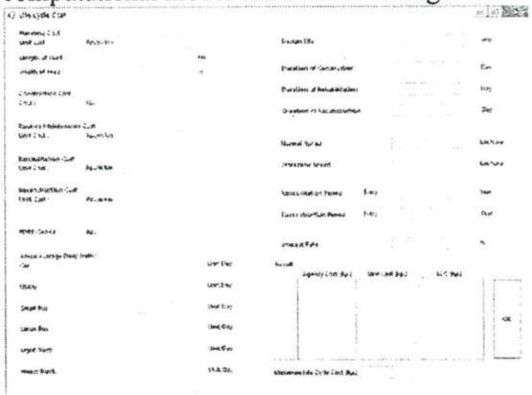

Figure 2. User Interface of Life cycle costing Computational Model

2.4 Analysis and Model Solution

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. In this case model has been tried to resolve the problem in a small-scale with hypothetical data.

The model has been developed then tested. The 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.

Capitalized worth method does not require the analysis period in the Life cycle costing calculation, because of the infinite life of road infrastructure asset (perpetual). Because without the analysis period the salvage value equal to zero.

The results of the Life cycle costing calculation by manual and computational model shown as below :

Tabel 3. Result of Life cycle costing in Manual

Variable	Alternative1	Alternative2
Agency Cost	Rp.33,161,007,667	Rp.27,577,341,954
User Cost	Rp.580,925,238	Rp.387,468,674
Total	Rp.33,741,932,905	Rp.27,964,810,628

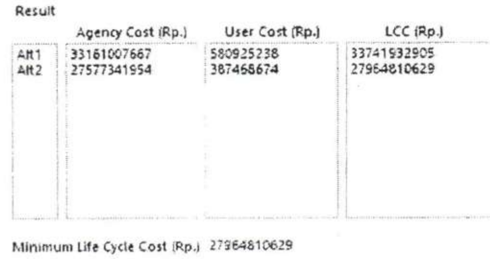

Figure 3. Result of Life cycle costing by Computational model

Validation technique is used to validate the computational model is "comparison to other models" by compare its result with manual calculation. Based on calculation from both way obtained the smallest value of Life cycle costing at alternative 2, it is flexible pavement with 20 years design life.

The sensitivity analysis aims to see how sensitive the decision to changes in values of input and internal parameters of a model to behavior model and the resulting output. In this research done by change the value of interest rate.

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 4.

Tabel 4. Recapitulation of Sensitivity Analysis to Changes in Iinterest Rate

Interest Rate	Alternative1	Alternative2
2.57%	Rp.51,543,083,112	Rp.38,482,934,617
3.42%	Rp.39,896,679,570	Rp.31,641,938,564
4.28%	Rp.33,741,932,905	Rp.27,964,810,628
5.14%	Rp.29,651,675,181	Rp.25,545,907,293
5.99%	Rp.26,740,923,101	Rp.23,844,957,443

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

3. CONCLUSION

1. Life cycle costing computational model can be used to calculate Life cycle costing with capitalized worth method.
2. Life cycle costing calculation both manual and computational model generate almost same result.

REFERENCES

Anonim. Mei 13, 2012. Deposit Rate. Accessed on May 13, 2012 at 20.00 pm from the http://pusatdata.kontan.co.id/v2/bungadeposito.Asian Development Bank (2003).

Road Funds and Road Maintenance-An Asian Perspective, Manila : Asian Development Bank.

Barringer, Paul (2003). A Life cycle costing Summary, Australia : Maintenance Engineering Society of Australia.

Bondsted, Hank (2009). Life cycle costing Analysis for Bridges : In Search of Better Investment and Engineering Decision, Pennsylvania.

Center for Research and Development of Transportation Infrastructure (2005). Road Management Technique, Bandung: Department of Public Works.

Department of Traffic and Transportation of East Java Province (2005). Study of Vehicle Operating Costs, East Java: Department of Traffic and Transportation Road of East Java Province.

Department of Education and Financial Training Center General Finance (2007). Principle and Technique State Property Management, Jakarta : Ministry of Finance of the Republic of Indonesia.

Directorate of Urban Road Development (1991). Maintenance Procedures for Rigid Pavement, Jakarta : Directorate General Bina Marga.

Department of Civil Engineering, Clemson University (2008). Life cycle costing Analysis for Pavement Type Selection. South Carolina : Clemson University.

Federal Highway Administration (1998). Life Cycle Analysis in Pavement Design.

Fuller, Sieglinde K and Stephen R. Peterson (1995). Life cycle costinging Manual for Federal Energy Management Program. Washington DC : Departement of Commerce USA.

Hicks dan Scholz (2003). Life cycle costing for Lime In Hot Mix Asphalt, Virginia : Oregon State University and Roadworthy Research & Design.

Indonesian Government Regulation No. 24 of 2005 about Government Accounting Standards.

Schade, Jutta (2007). Life cycle costing Calculation Models for Buildings. Luleå : Department of Civil, Mining and Environmental Engineering Luleå University of Technology.

Washington DC : US. Department of Transportation.

Kamil, Insannul, et al. (2012). Analysis of Factors Influencing Awareness of Road Maintenance as Public Asset Using Analytical Hierarchy Process (Case Study: Padang City Indonesia). International Conference on Asset and Facility Management. Padang Indonesia.

Kamil, Insannul, Alias, Buang and Hakim, Mohammed. (2012). Developing Model of Infrastructure Asset Maintenance in Developing Countries Using Fuzzy Screening System-AHP Approach (Case Study: Main Roads in Padang City, Indonesia). International Real Estate Conference. Kuala Lumpur. Malaysia.

Kamil, Insannul, et al. (2012). Designing Model of Database and Web GIS Application For Road Performance Management. 4th International Conference on Geoinformation Technology forNatural Disaster Management. Colombo, Sri Lanka

Kurniawan et al. (2011). Indonesia's Disaster Prone Index, Jakarta : Indonesian National Board for Disaster Management.

National Cooperative Highway Research Program (2002). Bridge Life cycle costing Analysis, Washington DC : Transportation Research Board.

New South Walles Treasury (2004). Life cycle costinging Guideline, New South Wales : New South Walles Treasury.

Paterson, William D. O. and Gandhi Harahap (2010). Performance-Based planning of Expenditure and Budgeting (PBK) at Directorate General Bina Marga, Jakarta : Indonesia Infrastructure Initiative.

Prayitno, Irwan. Mei 10, 2012. Per Capita Income in West Sumatra. Accessed on May 13, 2012 at 20.00 pm from the http://irwanprayitno.info/berita/aktual/1301552051-padang-paling tinggi.htm).

Regulation of the Minister of Public Works No. 20/PRT/M/2010 about Guidelines for Utilization and Usage Parts Way.

Suryaningsih, I Gusti Ayu (2010). Economic Studies Relocation of Roads And Bridges In Tabanan Road segment – Antosari, Bali : Universitas Udayana.

Syukrie, Abdullah and Abdul Halim (2006). Studies of the Capital Expenditure on Local Government Budget in association with Maintenance Budget and Sources of Income, Journal of Government Accounting, 2(2), 17-32.

Tenriajeng, Andi Tenrisukki (2002). Road Engineering-2, Jakarta : Guna Darma.