APPLYING VALUE ENGINEERING IN ROAD RECONSTRUCTION

BY USING RECYCLING TECHNIQUE

MUHAMMAD REVI FEBIANSYAH

UNIVERSITI TEKNOLOGI MALAYSIA

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MUHAMMAD REVI FEBIANSYAH

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DEDICATION

"To my beloved wife, mother, father, brothers, and sisters
for the Love and Support"

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ABSTRACT

Road plays an important role in the economic development of the country. Indonesia has ± 472.000 km of roads in its entire country. It is necessary to maintain function of the road in order to ensure maximum benefit to achieve the designated technical life span. There are various ways to maintain the road, it is based on the pavement distress condition and the structured capacity of existing pavement. Reconstruction is one of the efforts to maintain the road. Road reconstruction is usually done on road that the condition is badly damaged. The issue of cost and sustainable construction should be considered by the relevant institution to choice the most suitable design in road reconstruction. One method to respond to the issue of sustainable construction is the use of road recycling techniques, whereas the method which is used to improve the design value is value engineering (VE). The objective of this study is to establish designs of road recycling technique in road reconstruction work. The research instrument which is used in this study is case study. Three case studies are determined to exercise the application of value engineering (VE) on road reconstruction work by using recycling technique. These three case studies are the deteriorate road which located in West Java Province. VE is applied by following the VE job-plan: information phase, function analysis phase, creativity phase, evaluation phase, and development phase. The implementation of VE job-plan in each phase carried out by performing a simulation workshop. The simulation carried out by gathering some experts who are experienced in the field of road maintenance. The result of applying VE in such locations is four general designs for reconstructing road structural failure. The first design is AC-WC with PC filler + AC-BC + CMFRB-Base with PC filler + CTRB, the second design is AC-WC Modification + AC-BC + CMFRB-Base with PC filler + CTRB, the third design is AC-WC with PC filler + AC-BC + CMFRB-Base with Hydrate Lime filler + CTRB, and the last design is AC-WC Modification + AC-BC + CMFRB-Base with Hydrate Lime filler + CTRB. Difference cost of its designs has a range from Rp. 27.08 million to Rp. 60.45 million. VE can be applied in reconstruction work by using recycling technique. This can be a guide for clients to choose a design that suits their objective and desire.

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LIST OF ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
AC - BC	-	Asphalt Concrete – Binder Course
AC - WC	-	Asphalt Concrete – Wearing Course
ASTM	-	American Society for Testing and Materials
CBR	-	California Bearing Ratio
CESA	-	Cumulative Equivalent Standard Axle
CMFRB	-	Cold Mix Recycling Foam Bitumen
CMFRB Base HL	-	Cold Mix Recycling Foam Bitumen with Hydrate Lime Filler
CMFRB Base PC	-	Cold Mix Recycling Foam Bitumen with Portland Cement Filler
CTRB	-	Cement Treated Recycling Base
DCP	-	Dynamic Cone Penetrometer
FAST	-	Function Analysis System Technique
FHWA	-	The Federal Highway Administration
GEC	-	General Electric Company
HMRA	-	Hot Mix Recycling Asphalt
HMRA- BC	-	Hot Mix Recycling Asphalt -Binder Course
NBS	-	Navy Bureau of Ship
RAP	-	Reclaimed Asphalt Pavement
SAVE	-	Society of American Value Engineers
VE	-	Value Engineering
VM	-	Value Management
WVDOF	-	West Virginia Highways of Engineering

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CHAPTER 1

INTRODUCTION

1.1 Background

Road is one of the most promising and potent means for rapid industrialization and agricultural advancement. It plays an important role in the economy of the country. Road development has made significant contributions to economic growth and poverty reduction (Fan and Chan-Kang, 2005). Good transportation system with high structure ability, effective and efficient network is needed to give a contribution in a regional development, economic growth, human mobility, goods and services mobility, and at the end, will increase the national competitiveness.

At this time, the length of the national road in Indonesia is 38.600 Km, consist of asphalt pavement 85,38%, gravels 10,36 %, and natural soil 4,27%, with 87,72% in good condition (end of 2011). The management of the national road is the responsibility of the Ministry of Public Works. It is the government ministerial responsibilities for the planning, funding, construction, improvement and maintenance of the roads. However, in the local authority areas, the management of roads is the responsibility of the local authority itself. Government has high expectation in high value, proper function, and low cost construction.

It is necessary to maintain function of the road in order to ensure maximum benefit to achieve the designated technical life span and to achieve sustainable development. They are important, because they protect the asset values already in place. The performance of the pavement is measured in relation to the quality of service provided and the achievement of acceptable levels of service. It reduces and in some cases eliminates the need for expensive reconstruction in later years. Road

improvement and maintenance have supported the economic development and enhanced our life convenience greatly (Ando, 2005).

Maintenance activities for paved road are classified according to their frequency and their impact on the standards of the road. The categories are: routine maintenance, resurfacing, rehabilitation, betterment, reconstruction and new construction.

Various method and cost of construction for road maintenance are proposed by designer such as surface treatment (crack sealing, slurry seals), patching (surface patches, deep patching) and road recycling. With variation of cost of construction, saving cost is employer's constraint. Client always wants less cost, high quality, timely project completion, and improved value of such design.

A popular technique to fulfill client wishes is value engineering (VE). VE is an organized effort directed at analyzing the functions of goods and services for the purposes of achieving basic functions at the lowest overall cost, consistent with achieving essential characteristics (Younker, 2003).

1.2 Issues

Value engineering (VE) is the systematic review of a project, product, or process to improve performance, quality, and/or life-cycle cost by an independent multidisciplinary team of specialists. It is the focus on the functions that the project, product, or process must perform that sets VE apart from other quality-improvement or cost-reduction approaches.

Most of value engineering applies to big projects. According to FHWA Value Engineering Policy 1311.1A 2010, FHWA requires VE on each project using the Federal-Aid System with an estimated cost which includes project development, design, right of way, and construction costs of $25 million. Nevertheless, there is an opportunity to apply VE in small projects and personal purposes. VE which is

usually used on large projects actually can be applied to personal purposes, such as for a simple home planning (Ahda, 2006).

In the United States, VE, or more accurately, the value methodology (VM), has been used to improve transportation projects for more than 30 years. Traditionally, VE has been used by transportation agencies and municipal organizations to reduce or avoid excess capital construction expenditures. However, VE can play a broader role to support effective decision making for transportation projects to increase project performance and quality, balance project objectives, and manage community expectations.

Many transportation agencies now have project delivery strategies in place that incorporate VE and, in some cases, project funding approvals that are selectively tied to the completion of VE studies. The use of VE as a project management tool continues to grow and could be further enhanced by sharing information on the application and management of current VE practices and programs in North America (Wilson, 2005)

Road maintenance will always occur because when it has been opened to the public, it must be continually passed by various types of vehicles. There are many possibilities of road deterioration. The deterioration of paved roads is defined by the trend of its surface condition over time. The defects in a pavement surface, usually quantified through a pavement condition survey, are classified under three major modes of distress, namely: cracking (or fracture), disintegration and permanent deformation.

A major problem that faced by highway and transportation agencies is that the funds they receive are usually insufficient to adequate repair and rehabilitate every roadway section that deteriorates. The deterorioration occurs due to many factors including climate/weather, drainage, soil conditions, and truck traffic. Lack of funds often limits timely repair and rehabilitation of transportation facilities, causing a greater problem with more serious pavement defects and higher costs. The bad condition of road which is caused the structural failure can be repaired by implementing the reconstruction. Reconstruction will repair the layer of pavement from the bottom until the surface layer.

Deputy Minister of Ministry of Public Works of Indonesia states that 148 trillion Indonesian Rupiahs is needed to achieve the objectives of the 2010–2014 vision and mission of Indonesian Government for infrastructure development especially for road infrastructure. The current budget allocation indicates that if there is no breakthrough and innovation, the need for such amount of budget is hardly fulfilled by the current road financing system.

The two fundamental properties of a bituminous paving mixture that are held to be of the utmost importance are stability and durability. By stability is meant that property of the compacted mixture that enables it to withstand the stresses imposed on it by moving wheel loads without sustaining substantial permanent deformation. By durability is meant that property of the compacted mixture that permits it to withstand the detrimental effects of air, water, and temperature change. For succesful results, the pavement must be both durable and stable during its entire service life.

The others issue in road management is the issues of global warming, and the exploitation of natural resources. These issues have encouraged people to pay more attention to the environment and use the natural resources prudently. In many countries, including Indonesia, have promote the application of sustainable construction, which means the construction industry that are environmental friendly, energy saving and not ruin the environments.

Road reconstruction can be achieved by various ways, such as pave milling, deep patching or by using recycling technique. Recycling technique is the answer to the issue of sustainable construction. There is an opportunity to get designs with expected by VE method. At least there is a simple guideline and direction in every phase of VE method that can be done in road reconstruction by using recycling technique.

In Indonesia, there is no regulation or policy to use value engineering, but from the above discussion, it has been important for decision makers to apply the concept of value engineering in the implementation of road reconstruction especially reconstruction by using recycling technique. Since all government concern is to reduce the cost of public service projects without sacrificing quality.

1.3 Problem Statement

Road maintenance will always occur because when it has been opened to the public, it must be continually passed by various types of vehicles. A several issues that faced by highway and transportation agencies in order to maintain the road are; (1) lack of fund, and (2) the issue of sustainable construction.

All government including the highway agencies concern to reduce the cost of public service projects without sacrificing the quality. It needs breakthrough and innovation so that the implementation of road management can persist with limited funds. A popular technique to fulfill client wishes is value engineering (VE). VE is an organized effort directed at analyzing the functions of goods and services for the purposes of achieving basic functions at the lowest overall cost, consistent with achieving essential characteristics.

Road needs to maintain routine and periodically, the delay of timely repair and rehabilitation of transportation facilities, causing a greater problem with more serious pavement defects. Road with serious defect which is caused the structural failure can be repaired by implementing the reconstruction. Road reconstruction can be achieved by various ways, such as pave milling, deep patching or by using recycling technique. To overcome the issue of sustainable construction, the highway agencies can choose the recycling technique as a method to reconstruct the road.

Recycling technique is the reuse of material from existing pavements which are processed to provide quality paving materials suitable for use in new construction or in the rehabilitation of pavements. According to TRB (Transportation Research Board, 1980), there are several designs of road recycling techniques for road reconstruction works both for surface or base layer of pavement. With the design possibilities of each layer of pavement by using recycling technique, the identification of pavement recycling design is importance to analyze in order to seek the most appropriate design with the cheapest cost and the fastest execution time, without sacrifice the quality.

1.4 Research Question

The question that need to find the answer from this research is how many types of recycling design that can handle the road reconstruction works?

1.5 Objective of Research

Base on the problem statement and research question above, objective of the research is to identify the designs of recycling technique for road reconstruction by applying Value Engineering (VE) method.

1.6 Significance of Study

Client can take benefits in searching road recycling design options in achieving value of road reconstruction works using VE method.

1.7 Scope and Limitation of Study

1. The research location of this study is at three segment roads in Indonesia.
2. Road rehabilitation work is limited to the reconstruction of pavement layers.
3. Evaluation phase in VE is limited to quantifiable aspect (cost and time) and non-quantifiable aspects (constructability, quality, and complexity). Meanwhile, development phase in VE job-pan is limited to the pavement material cost.

1.8 Research Methodology

Methodology of this study is provided in Chapter 3. Generally, it divides into three stages: (1) study literature and data collection, (2) applying VE to get designs, and (3) conclusion and recommendation.

1.9 Thesis Organization

This study is composed of five chapters as follow:

Chapter 1 presents the introduction which is including background of the study, problem statement, objective of the study, scope, importance and methodology.

Chapter 2 presents the literatures review of road and value engineering application in construction.

Chapter 3 describes the methodology that adopted to conduct this research.

Chapter 4 will present applying VE in road reconstruction works by using recycling technique and discussion.

Chapter 5 will present the conclusion of the result of value engineering application process in road reconstruction works by using recycling technique and recomendation for the future study.

REFERENCES

AASHTO (1976). *Maintenance Manual*. American Association of State Highway and Transportation Officials, Washington D.C.

Ahda, S. A. (2006). Aplikasi Value Engineering pada Pengembangan Bertahap Sebuah Rumah. *International Conference on Construction Industry 2006: Toward Innovative Approach in Construction and Property Development.* UTM.

American Society of Civil Engineers (1971). *Criteria for Maintenance of Multilane Highways*. New York: No. 53.

Ando, R. (2005). Evaluation for Improvement Plan of Highways by Applying Value Engineering. *Journal of the Eastern Asia Society for Transportation Studies . Vol 6, pp.1021-1035*.

ASTM. (2006). *Standard Practice for Constructing FAST Diagrams and Performing Function Analysis During Value Analysis Study.* West Conshohocken: ASTM International.

British Standards Institution (1984). *Maintenance Management Terms in Terotechnology*. United Kingdom: (BS 3811).

Borza, J. S. (2011). FAST diagrams: The Foundation for Creating Effective Function Models. *13th Annual TRIZ Conference*. 28-29 November. Detroit, USA.

Chung, B. Y., Syachrani, S., Jeong, H. S., & Kwak, Y. H. (2009). Applying Process Simulation Technique to Value Engineering Model: A Case Study of Hospital Building Project. *Vol. 56, No. 53.*

Davis, M. E., & Merton E. Davis, J. D. (1977). *Value Analysis Value Engineering-The Implications for Managers.* Taraporevala Publishing Industries Private Limited.

Dell'Isola, A.J. (1982). *Value Engineering in the Construction Industry.* Van Nostrand Reinhold, New York.

Didik Purwadi (2008). *Buku Ajar: Jalan Raya 2 (Perkerasan Jalan)*. Universitas Diponegoro. Semarang.

Fan, S., & Chan-Kang, C. (2005). *Road Development, Economic Growth, and Poverty Reduction in China.* Washington: International Food Policy Research Institute.

Fisk, E. R. (1997). *Construction Project Administration*. (5th Edition). Prentice Hall, New Jersey.

Garber, N. J., & Hoel, L.A. (2009). *Traffic and Highway Engineering*. (4th edition). Toronto, Ontario: Thomson Learning.

Hermanto Dardak, A., Dr. *The State of The Art in the Field of Road Development in Indonesi*a. Opening speech on Joint Workshop between the Government of the Republic of Indonesia, National of Land and Infrastructure Management (NILIM) – Japan, Public Work Research Institute (PWRI) – Japan, and Research and Development Centre for Road and Bridge – Indonesia, Bandung, Indonesia. 2nd March, 2010.

Hoyle B & J Smith (1998). Transport and Development: Conceptual Frameworks. In: Hoyle B & R Knowles (eds.) (1998). Modern Transport Geography. 2nd edition. 373 pp. John Wiley & Sons. New York, USA.

J.A. Epps, R.L. Terrel, and D.N. Little. "Recycling Pavement Materials," *Rural and Urban Roads*, May, 1978.

Joe (2011). Towards the Sustainable Construction, Main Report, Jakarta, *Kiprah Bulletin, Vol. 47/2011.*

Judith Bell (2005). *Doing Your Research Project: A Guide for First-Time Researchers in Education and Social Science*. (4th Edition). Berkshire, England: Open University Press.

Lay, M. G. (2009). *Handbook of Road Technology*. (4th ed.). Milton Park, Abingdon: Spon Press.

Oguara (2001). *Pavement Maintenance Management Systems: the Pragmatic Decision-Making Tools for Highway Engineers*. Inaugural Lecture. Faculty of Engineering, Rivers State University of Science and Technology, Port Harcourt., Nigeria. 8th August, 2001.

SAVE International (2007). *Value Standard and Body of Knowledge*. SAVE International Value Standard.

S.G. Philliber, M.R. Schwab, & G.S. Sloss (1980). *Social Research: Guides to a Decision-Process.* Itasca, IL: F. E. Peacock Publishers, Inc.

S.W. Hudson, B.F. McCullough, and R.F. Carmichael. (1986). *Aggregate and Paved Surface Design and Rehabilitation Manual for Low-Volume Roads*. Draft Report. Federal Highway Administration US. Department of Transportation: Washington.

William D.O. Paterson (1987). *Road Deterioration and Maintenance Effects-Models For Planning and Management*, Washington D.C., A World Bank Publication

Wilson, D. C. (2005). *Value Engineering Applications in Transportation*. Washington: Transportation Research Board.

WVDOH (2004). *Value Engineering Manual*. West Virginia Department of Transportation Division of Highways Engineering. West Virginia: WVDOH Office Service Divison.

Younker, D. L. (2003). *Value Engineering Analysis and Methodooogy*. New York: Marcel Dekker, Inc.

Zainab, A. A. and M. Zahry O. (2006). Achieving Sustainable Construction in the Development Countries of South East Asia. *Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006)*, 5 – 6 September 2006, Kuala Lumpur, Malaysia, C-29.