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Value Engineering on Martadinata (Pamulang) Flyover Construction

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Abstract: ***Currently, the government has launched an acceleration of infrastructure development for economic growth. However, the government funds are very limited, hence, cost savings and efficiency are required. Transportation infrastructure is one of the jobs that often absorb a large portion of the funds. Projects that use large funds allow budget inefficiencies to occur, therefore the implementation of Value Engineering efforts is a solution to optimize the value of benefits while reducing unnecessary costs. Value Engineering is a systematic organized business, with a product or service function identification technique that aims to fulfill the required function at the lowest (most economical) price and Life Cycle Cost is the process of determining the sum of all costs associated with an asset or part of an asset, including acquisition, installation, operation, maintenance, renewal and removal costs. The application of Value Engineering is expected to produce optimum value in terms of quality, technology, efficiency and project innovation. This research was conducted to determine the best alternative in implementing Value Engineering and to find out the cost savings obtained from the application of Value Engineering. In this study, an analysis of two alternatives will be carried out, there are. I. combination of PCU girder with corrugated steel and foam mortar light deposit, and II corrugated steel and light heap of foam mortar. The method used is the value engineering analysis of the two alternatives. In the value engineering method, there are several stages that must be carried out, there are, the information stage, the function analysis stage, the creative stage and the development stage. The results showed that from 2 (two) alternatives, the second alternative was obtained with the most economical bridge structure, while alternative I was the next alternative.***

Keywords: Value Engineering, Efficiency / Savings

1. Introduction

1.1 Background

The primary arterial road function is a national road network system with continuous movement and high traffic volume to ensure a smooth traffic. In theory, the ideal intersection is an unlevel intersection. The type of unlevel crossing construction that can be built is fly over or underpass.

In 2012, the National Road Implementation Center VI of the Ministry of Public Works in collaboration with PT. Mekaro Daya Mandiri has conducted a feasibility study using the review of fly over at the Martadinata road junction - which is the intersection with Dr. Setia Budi street construction – Cabe Raya road in Pamulang, South Tangerang City, Banten Province suitable to be built in an effort to overcome the congestion problem that has been existed. In the construction planning, the Martadinata Fly Over is designed with a length of 363.1 m, with an overall effective length of 983.53 m and a road widening length of 1240m. The total budget for the construction of the Martadinata fly over is planned at Rp 138 billion. With a fairly large development budget, value engineering is required in optimizing costs and/or performance to be more efficient and optimal, with the support of government in implementation of Value Engineering in construction projects.

In order to achieve economic growth, the government has launched an acceleration program for infrastructure development. Meanwhile, the available government funds are very limited therefore cost savings and efficiency are necessary. Transportation infrastructure work is one of the jobs that often uses a very large budget. Projects that use large funds, allow budget inefficiencies to occur.

According to the Regulation of the Minister of Public Works Number: 06/PRT/M/2008concerning the Supervision of Implementation and Implementation of Construction Inspections within the Ministry of Public Works Guidelines states that inspections can be carried out at the planning stage of construction works and implementation of construction works if any indication of inefficiency (waste) is found due to the unfairness of construction prices, analysis of construction type/type selection, construction calculations, and construction methods, therefore, Value Engineering will be recommended to be carried out for both Service Users and Service Providers.

The implementation of Flyover Construction in the big cities are expected to be the reference of value engineering of other project alike in the future, the success of value engineering application can be useful to achieve efficiency of development funding in macro level.

Thus, to achieve efficiency in terms of job quality and cost, value engineering in development stage are necessary.

Moreover, it will show an increased in value and reduction of cost and better alternative material substitutes

1.2 Problems Statement

1) What are the most efficient and effective alternatives structure elements in implementing Value Engineering of Fly Over Martadinata Pamulang Construction Project.
2) How much is the cost savings obtained from the application of Value Engineering on the Fly Over Martadinata Pamulang.

1.3 Research Objectives

The purpose of this research is:
1) To determine the best alternative structure elements in Value Engineering implementation to the Fly Over Martadinata Pamulang development project.
2) To obtain the cost savings result from the application of Value Engineering on the Fly Over Martadinata Pamulang.

2. Literature Review

Definition of Value Engineering

Value Engineering is a systematic, organized approach which has been approved, that includes identifying product and service utilization to provide necessary functions in a project at the lowest cost (most economical) Soeharto (2014).

The application time for Value Engineering

The Value Engineering can be applied at a certain period of time. Planning stage is a crucial time to apply Value Engineering in order to achieve maximum result. Velue engineering should be started early at concept stage and nd continuously at intervals until the completion of planning. Planning decisions made by stakeholders will have a very great influence on the use of resources during the construction phase.

Cost

Cost is the sum of all the effort and expenditure incurred in developing, producing and applying the product. Manufacturers always take consideration on the impact of costs on quality, durability, and maintenance as it affects costs for users.

Function

Understanding the meaning of function is crucial in studying value engineering as the function will be the main object in relation to cost. The use of verbs and nouns are the key to identify the functions.

Value

Value is a measure of consumer satisfaction with goods or services that have been purchased, in terms of quality, reliability and price. The ability of the product to provide a satisfying use function, compared to the price paid is referred to as use value. While the cost value is the cost required to produce a product which is the total amount of labor, materials and overhead costs.

Value Engineering Work Stage

Value engineering will be carried out by a multidisciplinary group of experienced people to follow the value engineering job plan (VE Job Plan) systematically. A job plan is an sequential approach to carry out a VE study consisting of several stages or phases to focus on the VE team's analysis so that innovation process can be collectively rather than uncoordinated by individual innovations SAVE Standard, (2007). The phases are:

1) Information Phase
2) Creative Phase
3) Evaluation Phase
4) Development Phase
5) Presentation and Follow Up Phase

Life Cycle Cost (LCC)

According to Dell'Isola, (1997), LCC is the total cost from the initial planning stage until the end of the utilization of a facility. The elements of LCC are investment costs, financing costs, operational costs, maintenance costs, change costs, taxes and salvage value. Model LCC akan dilakukan identifikasi area - area yang memiliki biaya siklus hidup yang tinggi. The LCC model will identify areas that have high life cycle costs. Users/owners and planners set the interest or discount rate to be used in the analysis process.

3. Research Methodology

3.1 Research Location

The object of this research is the Fly Over Martadinata (Pamulang) Development Package on Jalan R. E Martadinata, South Tangerang City, Banten Province.

3.2 Data Collection Method

Data used in this research is grouped into 2, there are:

1) Primary Data

Primary data is the basic data used in conducting value engineering analysis. Data gathered by using direct surveys, such as interviewing staff of the consultant handling the Martadinata Fly Over Development project and observations. Primary data can be in the form of technical data from the project, such as plan drawings, Budget Plan, and implementation schedule.

2) Secondary Data

Secondary data is supporting data that can be used as input and reference in Value Engineering analysis. It includes data on unit price lists and worker analysis, material information or usage, data on heavy equipment, labor data, regulations regarding bridge building structures that can be used as references in analyzing Value Engineering.

3.3 Research Flow Chart

The research flow chart shows the phases of research conducted.

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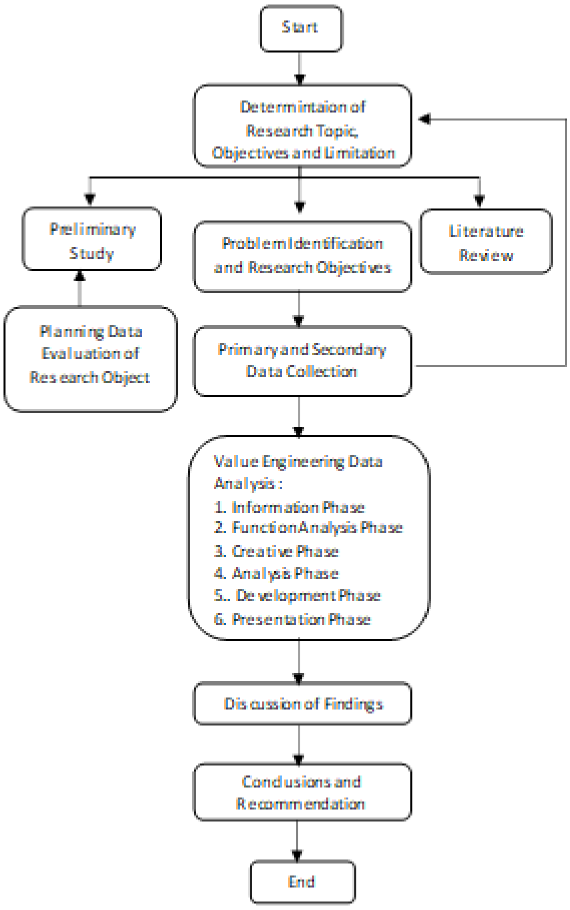


Diagram 1: Research Flow Chart

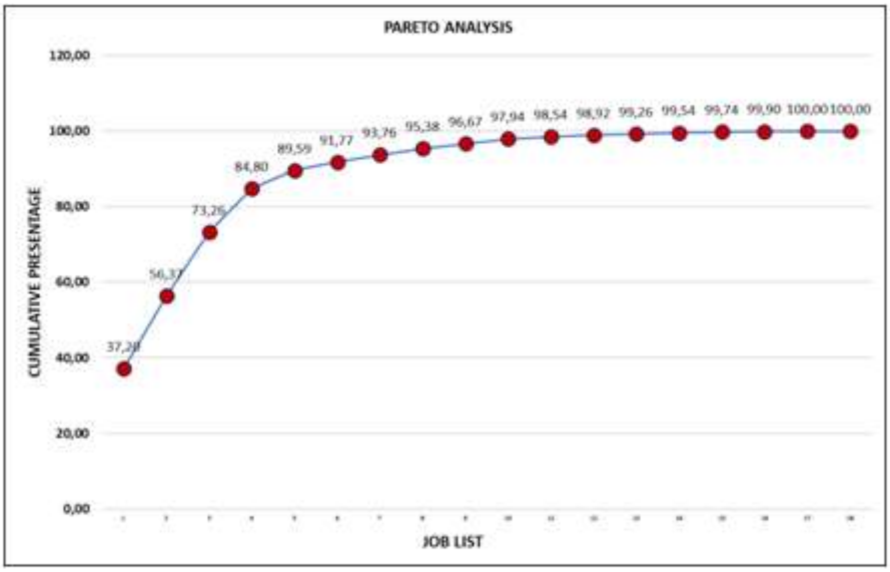
Table 1: Pareto Analysis Result

Payment Item No.	Description	Unit	Price	Percentage (%)	Cumulative Percentage (%)
a	b	c	d	e	f
	DIVISION 7. STRUCTURE				
7.2 (3)a	Supply and Installation of 35 meters U-type girder precast unit	Unit	32.289.422.416,89	37,20	37,20
7.6 (19) b	Concrete Drill Pile with diameter 1000 mm	M'	16.643.460.020,20	19,17	56,37
7.1 (5) c	Medium quality concrete fc'30 Mpa + Reinforcement Steel (Pier, Abutment, Pile Cap, and Bottom Beam)	M^3	14.655.865.453,96	16,88	73,26
7.1 (5) a	Medium quality concrete fc'30 Mpa + Reinforcement Steel (floor plate and backrest)	M^3	10.017.005.330,68	11,54	84,80
7.2 (3)b	Supply and Installation of Precast Unit Type U Span 40.8 meters	Unit	4.159.933.601,88	4,79	89,59
7.6 (27) a	Cross hole sonic logging (CSL) testing on 1000mm diameter concrete drill piles	Unit	1.892.367.411,49	2,18	91,77
SK7.17	MSE-Wall	M^2	1.726.430.775,65	1,99	93,76
7.13.(1)	Railing	M'	1.400.928.969,18	1,61	95,38
7.12.(3)	Laying Elastomeric Bearing Size 650 x 700 x 69 mm	Unit	1.121.717.867,18	1,29	96,67
7.6 (11) c	Provision and Piling of Precast Prestressed Concrete Piles measuring 22x22x22 cm (triangle multiple)	M'	1.104.924.584,22	1,27	97,94
7.6 (27) b	PDLT (Pile Dynamic Load Testing) Type Dynamic Load Testing On Pile Size 1000mm	Unit	518.485.000,00	0,60	98,54
7.11.(1) a.	Asphaltic Plug Type Expansion Joint	M'	329.605.479,65	0,38	98,92
7.1 (5) c	Medium strength concrete fc'30 Mpa + Reinforcement Steel (reinforced box culvert)	M^3	292.673.883,85	0,34	99,26
7.1 (7)	Medium quality concrete fc'20 MPa + Reinforcement Steel (Tread Plate and Wing Wall)	M^3	245.550.417,46	0,28	99,54
7.16.(1)	Deck drain	Unit	175.727.251,57	0,20	99,74
7.16.(3).d	PVC Drainage Pipe with diameter 200 mm	M'	140.737.739,50	0,16	99,90
7.1 (10)	Low strength concrete fc'10 Mpa for work floors	M^3	82.202.096,68	0,09	100,00
7.14.(1)	Bridge Nameplate	Unit	2.211.110,00	0,00	100,00
			86.799.249.410,02	100,00	

4. Discussion

Information Phase

Based on Pareto Analysis Result, Pareto Graph result and *Breakdown Cost Model*, in the implementation of the Martadinata Fly Over Construction Project, the job that has the greatest load is the bridge structure work.



Graph 1: ParetoAnalysis of Job Structure Pekerjaan

From the results of the Pareto analysis on the work of the Structure Division, the work items were then determined to be analyzed in Value Engineering are the work on the provision and installation of a 35 m U type girder precast unit, 1000 mm diameter concrete drill pile, medium quality concrete fc'30 MPa + steel reinforcement (Pier, Abutmen, Pile Cap, and Bottom Beam), Provision and installation of a 40.8 m span U - type girder precast unit, Elastomeric Bearing Positioning Size 650 x 700 x 69 mm and Expansion Joint Type.

Creative Phase

The aim of this phase is to obtain and develop alternatives on cost - efficient job items that has been analyzed using Pareto in information phase.

The following are the alternatives:

1) Alternative 0: (Original according to Detailed Engineering Design / Specifications)
2) Alternative I: Upper Building Using PCU Girder with a length of 40.8 m in the middle span with Corrugated Steel span 24 m 2 pieces, and Lower Building using a light heap of foam mortar.
3) Alternative II: The Upper Building uses 3 pieces of Corrugated Steel with a span of 24 m 2 pieces and 26 m 1 pieces, and the Lower Building uses a light heap of foam mortar.

Evaluation Phase

This phase is aim to evaluate the alternatives submitted in creative phase, which then will be made as decision. Some of the items that will be reviewed at this phase are:

a) Cost Comparison on each alternative that is carried out by Value Engineering.
b) Cost Comparison on each alternative in the Structural Division.
c) Comparison of the costs of each alternative against the whole project.

a) Cost Comparison on each alternative that is carried out by Value Engineering.

Table 2: Cost comparison on value engineering alternatives

No.	Design	Cost (Rp)
1	Original Condition	69.200.004.839, 75
2	Alternative I	57.975.473.697, 51
3	Alternative II	40.361.760.142, 13

The cost of the intial design of the Fly Over structure jobwas Rp.69.200.004, 839.75 and after the VE analysis is carried out, the alternative cost I is Rp.57, 975, 473, 697.51 with a savings of Rp.11, 224, 531, 142.24 or 16.22% and the cost of alternative work II is Rp.40, 361, 760, 142.13 with a savings of Rp.28, 838, 244, 697.62 or 41.67%.

b) Cost Comparison of each alternative in the Structure Division

Table 3: Cost Comparison on Structural Division

No.	Design	Cost (Rp)
1	Original Condition	86.799.249.410, 02
2	Alternative I	69.287.642.619, 05
3	Alternative II	51.553.104.392, 23

The cost of job on the initial design of the Fly Over structure division was Rp.86, 799, 249, 410.02 and after the VE analysis was carried out, the alternative cost I was Rp.69, 287, 642, 619, 05 with a savings of Rp.17.511.606.790.97 or 20.17% and the cost of alternative work II is Rp.51, 553, 104, 392.23 with savings of Rp.35, 246, 145, 017.79 or 40.61%.

c) **Cost Comparison of each alternative to the whole project**

Table 4: Cost comparison on entire project

No.	Design	Cost (before tax) (Rp)
1	Original Condition	12.116.152.245, 51
2	Alternative I	108.604.545.454, 55
3	Alternative II	90.870.007.227, 72

The overall work cost of intial design of the Fly Over project was Rp.126.116.152.245, 51 (without VAT) and after the VE analysis, the alternative cost I is Rp.108.604.545.454.55 with a savings of Rp.17.511.606.790.97 or 13.89% and the cost of alternative work II is Rp.90, 870, 007, 227.72 with a savings of Rp.35, 246, 145, 017.79 or 27.95%.

Development Phase

Life Cycle Cost (LCC)

Before calculating the cost of Life Cycle Cost (LCC), it is necessary to know the cost of the components in the Structure division that have replacement costs, maintenance, since the estimated costs greatly affect Life Cycle Cost (LCC).

Initial Cost

Initial cost is obtained from the calculation of the Budget Plan on the three selected alternatives. This Budget Plan is calculated based on the materials used and the cost of the work methods used as well as any special tools needed to complete the job of the three selected bridge alternatives. For alternatives I and II there is an estimated additional cost for Redesign, with an estimated cost of IDR 200, 000, 000.00. The results of the RAB calculations to carry out the construction of the three designs can be seen in Table 5.

Table 5: Initial Cost

Item	Original Condition	Alternative I	Alternative II
Construction Cost	Rp 69.200.004.839,75	Rp57.975.473.697,51	Rp40.361.760.142,13
Redesign Cost	-	Rp200.00.000,00	Rp200.000.000,00
Total Initial Cost	Rp69.200.004.839,75	Rp58.175.473.697,51	Rp40.561.760.142,13

Construction Life Expectancy

The life expectancy of the bridge construction plan is 50 years. .

Interest Rate

According to interest rate data from Bank Danamon in 2020, the interest rate used in this porject is 10%.

Maintenance Cost

Maintenance costs (Maintenance Cost) consists of two items; maintenance costs and replacement costs. The cost of maintaining Concrete and Steel Structures according to Bonstedt (2014) is 0.05% of the initial construction cost (Initial Cost) each year during the design life, work items such as sign maintenance, railing maintenance, cleaning of drifting goods and painting of bridges and thermoplastic road markings. .

Table 6: Maintenance Cost

Item	Original Condition	Alternative I	Alternative II
Initial Cost	Rp 69.200.004.839,75	Rp58.175.473.697,51	Rp40.561.760.142,13
Maintenance Cost= 0,05% Initial Cost	Rp34.600.002,42	Rp29.087.736,85	Rp20.280.880,07
P/ A Factor (n=50, i= 10%); (9,915)	Rp343.052.605,25	Rp288.399.514,71	Rp201.081.163,54

Replacement Cost

Replacement Cost elements, including replacement of pavement layers and replacement of expansion joints, A layer of asphalt concrete (Laston) worn layer AC – WC is used as a pavement layer on the bridge structure that will be reviewed. Asphalt concrete layer (Laston) AC – WC has a design life of five years, so every five year period it must be replaced with new components in order to continue to support safety and comfort for road and bridge users. The cost calculation used is derived from the total unit cost of AC – WC asphalt concrete layer (Laston) work which has previously been calculated in the bridge construction budget. In the initial/existing condition and Alternative I there is an expansion joint, which at the time of replacing the AC - WC layer, this work item was also replaced, in alternative II there was no expansion joint on the bridge.

Table 7: Replacement Cost

Job Type	Replacement Cost		
	Initial Cost (Rp)	Alternative I (Rp)	Alternative II (Rp)
Asphalt Pavement Layer Replacement every 5 years	2.264.626.771	1.832.641.730	1.736.645.054

Salvage Value

Salvage Value is the value at the end of the investment period / plan life. Salvage Value or residual value according to Bonstedt (2014) for Concrete Structures is 0%, while for Steel Structures it is 2% of the initial cost (Initial Cost). In the initial condition design of the bridge structure using concrete which is impossible to resell so there is no residual value, while in alternative I and II the bridge structure uses Corrugated Steel, so there is a salvage value in this alternative II design.

Job Type	Salvage Value		
	Initial Cost (Rp)	Alternative I (Rp)	Alternative II (Rp)
Corrugated Structural Steel Supply and installation	-	96.616.960,57	150.577.247,48

Table 9: Cost Saving Initial Cost and LCC

No.	Design	Initial Construction Cost		Life Cycle Cost	
		Price (Rp)	Efficiency (%)	Price (Rp)	Efficiency (%)
1	Original Condition	69.200.004.840	-	71.807.684.216	-
2	Alternative I	58.175.473.698	15,93	60.199.897.982	16,17
3	Alternative II	40.561.760.142	41,38		

Cost - savings Calculation

Table 10: Cost Saving Replacement Cost and Maintenance Cost

No.	Design	Replacement Cost		Maintenance Cost	
		Price (Rp)	Efficiency (%)	Price (Rp)	Efficiency (%)
1	Original Condition	2.264.626.771	-	343.052.605	-
2	Alternative I	1.832.641.730	19,08	288.399.515	15,93
3	Alternative II	1.736.645.054	23,31	201.081.164	41,38

5. Conclusion and Recommendation

5.1 Conclusions

Based on the research conducted, the conclusion can be drawn are as follows:

1) There are 2 (two) alternative that are applicable in Martadinata Pamulang Fly Over Construction; there are alternative I, a combination of PCU girders with 2 pieces of corrugated steel span and 2 pieces of foam mortar light stockpile, and alternative II of 2 pieces of corrugated steel span 24 meters and span 26 meters 1 piece, with a light pile of foam mortar.
2) The value of construction costs after Value Engineering is carried out are:
   - Alternative I to the Initial Condition, experienced a decrease in construction costs by Rp.11, 024, 531, 142.24, - or 15.93%
   - Alternative II to the Initial Condition, experienced a decrease in construction costs by Rp.28, 638, 244, 697, 62, - or 41.38%.
3) The value of Life Cycle Cost (LCC) after Value Engineering is carried out are:
   - Based on the analysis of the cost of the bridge with life cycle of 50 years; Alternative I costs Rp.60, 199, 897, 981, 71. There was a cost savings of Rp.11, 607, 786234, 62, - or 16.17%. between Alternative I and Initial Conditions.
   - Alternative II costs Rp.42, 348, 909, 112.42, - . There is a cost savings of Rp.29, 458, 775, 103, 91, - or 41.02% between Alternative II and Initial Conditions.

6. Suggestion

Based on the analysis that has been conducted, below are some of the suggestion:

1) In bridge construction project, value engineering analysis is very crucial as it is related to the issue in estimating construction costs that can be obtained by the owner / company in order to be more cost - efficient.
2) In establishing a new design, the analysis results of the value engineering team should be align with the relevant parties to get more realistic design to be implemented in the field.
3) The application of value engineering should be carried out before project implementation begins in order to achieve cost - efficiency objectives.
4) The regulation governing the implementation of Value Engineering which covers all areas of substance within the Ministry of PUPR, both in the fields of water resources, roads and bridges, as well as other creations, are needed.
5) The application of Value Engineering are not only beneficial to jobs with large percentage of costs, but also for other jobs that have potential savings such as non - asphalt pavement and drainage.

7. Recommendation

Below are the recommendation gain from the research:

1) Based on this study, the authors recommends using Alternative II with Corrugated steel structures spanning 24 m 2 and span 26 m 1 and Mortar Foam Light Heap as a replacement for the initial design because it reduced cost both in terms of construction costs and life cycle costs.
2) Since many replacement materials - with a cheaper prices, accessibility and higher quality, are available, there will be more alternatives gained from it. Therefore, value engineering result can be more varied.
3) To get optimal savings, Value Engineering can be used at every stage of the project, starting from the concept, planning to the implementation stages, especially on large projects with a large number of work items.

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