Sustainable Civil Building Management and Engineering Journal Vol: 1, No 4, 2024, Page: 1-10

Implementation Of Value Engineering Using Analytical Hierarchy Process (Ahp) (Case Study: Flyover Construction Project Of Jpl 64 Km 38+897 Across Surabaya – Solo)

Naufal Akbar Muazaky*, Fajar Sri Handayani, Ary Setyawan

Sebelas Maret University

DOI: https://doi.org/10.47134/scbmej.v1i4.3077
*Correspondence: Naufal Akbar Muazakay
Email: naufalmuzaky2467@gmail.com

Received: 12-05-2024
Accepted: 19-06-2024
Published: 25-07-2024

Abstract: The development of infrastructure development in Indonesia is being intensively carried out by the government to meet the needs of the community. Infrastructure development is often faced with various obstacles that can disrupt the project. To ensure the sustainability of the project, it is necessary to apply Value Engineering to identify opportunities for cost savings and solve problems so as to get maximum value without reducing project quality. The purpose of the research is to analyze the structure, determine the alternative, types and construction methods chosen to make the project cost efficient. Value Engineering is applied to the foundation and deck slab work of the Fly Over Replacement Construction Project JPL 64 Km 38-897 Lintas Surabaya-Solo using the AHP method with the help of expert choice. Based on the results of the Value Engineering analysis, an alternative bore pile d-120 foundation was obtained in the foundation work and a change in the cantilever elbow support method in the deck slab work. The cost efficiency results obtained after Value Engineering amounted to Rp15,108,214,225 or 10%.

Keywords: Value Engineering, AHP, Expert Choice

Introduction

Sidoarjo is one of the major districts in East Java Province. The industrial sector in Sidoarjo Regency is growing quite rapidly because of its geographical location adjacent to the capital city of East Java Province, namely Surabaya, which is the business center of East Java Province. This makes Sidoarjo Regency one of the districts with the largest population in East Java with a population of 2,082,801 people (BPS Sidoarjo Regency 2020). To support the industrial economy in Sidoarjo City, a lot of infrastructure development is carried out to meet the needs and mobilize the existing economy(Alsanabani, 2023; Chang, 2022; Lin, 2024)

One of the steps taken by the Sidoarjo Regency Government is the Fly Over Construction Project to replace JPL 64 Km 38 + 897 Surabaya – Solo. This fly over project was built to overcome the problem of traffic congestion on the JPL 64 Krian Sidoarjo Railway Crossing, due to the existence of rivers, illegal buildings, intersections and railway crossings adjacent to the main road to Krian Market which is the center of activity. This has led to an increase in the volume of vehicles passing through the intersection every day(Bahadori, 2022; Darban, 2021; Saud, 2022).

In the implementation of construction projects, there are often various obstacles that can interfere with the progress of the project. According to (Puspitasari et al., 2020) There are several factors that can interfere with the implementation of the project, including lack of labor expertise, material quality inconsistencies, managerial errors, and budget constraints. The problem of project budget limitations is one of the factors that can pose a risk to the continuity of the implementation of construction projects(Abudeif, 2017; Marfuah, 2017; Nursetyowati, 2019).

(Kencana & Waty, 2021) in his research journal, it defines that Value Engineering is a technique that provides functionality in a component or product at the lowest cost while meeting quality, performance, and reliability specifications. According to SAVE (Society of American Value Engineers), Value Engineering is a method focused on systematic application that involves a team of professionals to analyze and increase the value of a product, facility design, system, or service(Moarab, 2015).

In Indonesia, Value Engineering (VE), has been regulated based on the regulation of the Public Works Office Number 222/KPTS/CK/1991 of the Directorate General of Cipta Karya, VE analysis is required for construction projects with work costs exceeding 1 billion.

The above considerations are the background of a study conducted with VE analysis on the Fly Over Construction Project to replace JPL 64 Km 38 + 897 Surabaya – Solo. By conducting research using the VE method, it is hoped that the effectiveness and efficiency of cost savings from the project will be obtained to solve problems and be used as a reference for future development projects.

Methodology

This research applies five stages to ensure the smoothness and accuracy of the results called the Value Engineering Job Plan, namely the information stage, the function analysis stage, the creative stage, the evaluation stage, the development stage, and the presentation stage. In the analysis stage, the Analytically Hierarchy Process (AHP) method is used with the help of Expert Choice Software

This research was carried out on the Fly Over Construction Project to replace JPL 64 Km 38 + 897 Surabaya – Solo, Jeruk Gamping Village and Krian Village, Krian District, Sidoarjo Regency, East Java Province with a bridge length of 550 m.

Figure 1.1 Location of Development Projects Fly Over Replacement for JPL 64 Km 38+897 Surabaya – Solo

According to (Knowledge, 2007), there are 3 phases of stages in Value Engineering that is:

1. Pre-Workshop Phase, is a stage that is carried out to make improvements to existing problems and determine in detail the aspects of the problem that will be handled.
2. Workshop Phase. At this stage, it is divided into 3 stages, namely:
   a. The information stage is the initial stage in Value Engineering analysis with the collection of data and information about the project, cost breakdown, and pareto distribution law.
   b. The function analysis stage is a stage to analyze the functions that arise without increasing costs.
   c. The creative stage is the stage of identifying alternatives solutions that arise and can be analyzed for Value Engineering based on existing information.
   d. The evaluation stage is a critical stage to assess and analyze existing alternatives.
   e. The development stage is the stage to produce the best alternative solution by comparing the existing conditions with the selected alternative conditions.
   f. The recommendation stage is a presentation stage in the form of a final report from the selected alternative and attaching considerations in accordance with the results of the analysis.
3. The Post-Workshop Phase, is a stage to ensure that the selected alternatives are implemented and the expected benefits are achieved.

Result and Discussion

Information Stage

The Fly Over Construction Project to replace JPL 64 Km 38 + 897 Surabaya – Solo functioned to overcome the problem of traffic congestion at the railroad due to rivers, illegal buildings, and facilitate people's economic activities. The construction of the fly over project has a contract value of Rp. 157,113,547,000. The following are the results of the cost breakdown analysis presented in Table 1.

Table 1 1 Cost Breakdown RAB Project Fly Over

N0	WORK ITEMS	COST	FEE PERCENTAGE	CUMULATIVE PERCENTAGE
1	Common	IDR 6,510,268,010	4%	4%
2	Civil	IDR 4,835,488,938	3%	7%
3	Bridge	IDR 130,235,633,285	83%	90%

From Table 1.1, it can be seen that the bridge work has a broken cost with a weight of 83%. Value Engineering can be done if it has a percentage of work that is more than 80% of the total project cost. So the focus of research in this study is bridge work. The results of the pareto analysis are presented in Figure 1.2 below

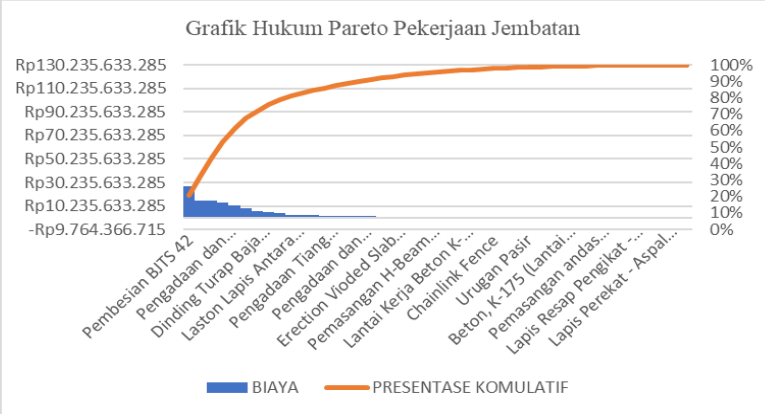

Figure 1. 2 Pareto Bridge Work Legal Chart

Based on the results of the pareto distribution, it was found that the work that has the potential to be carried to Value Engineering in the Fly Over Construction Project to replace JPL 64 Km 38 + 897 Surabaya – Solo is on the work items of procurement and piling as well as K-350 quality concrete work which in this study will focus more on the deck slab work method.

Function Analysis Stage

The first thing to do is to identify the functions of the selected work items at the information stage consisting of verbs and nouns and grouped them based on basic functions and supporting functions.

Creative Stage

At this stage, there are several alternatives to the foundation work item to obtain cost savings and efficiency. Alternative foundations offered are bore pile foundation d-80, bore pile foundation d-100, bore pile foundation d-120, and square pile foundation dia 45 x 45 cm. For deck slab work items, there is a change in the cantilever support work method (hanging iron) to the cantilever elbow support method.

Evaluation Stage

In the evaluation stage, the ideas generated from the creative stage will be identified, and the elimination of ideas that are not possible will be eliminated. The advantages and disadvantages of each idea will be identified and considered at this stage. The evaluation stages are carried out on foundation work and deck slab work.

1. Foundation Work

Pole Carrying Capacity Analysis

At this stage of analysis, it is carried out to determine the carrying capacity of the pole permit and ensure that the foundation is able to safely withstand the structural load of the building.

Table 1.2 Recapitulation of the Bearing Capacity of the foundation at a depth of 40 m

No	Types of Foundations	Diameter (m)	Number of poles	Group Carrying Capacity (kN)

				Allowable Carrying Capacity per 1 Pole (kN)	
1	Bore Pile d-80	0.8	6	213.8852	1202.5102
2	Bore Pile d-100	1	5	286.2061	1340.9284
3	Bore Pile d-120	1.2	4	366.0668	1399.1885
4	Square Stake 45 x 45	0.45	8	282.2223	1655.7041

Analysis of Unit Price of Foundation Work

At this stage, an analysis of the price of each alternative foundation work is carried out to see the cost of the work which will later be compared to the existing cost.

Table 1.1 Recapitulation of Existing Foundation Work Costs

No	WORK ITEMS	Sat.	Existing (TP60 & BP120)		
			Volume	Unit Price	Price Amount
1	Procurement of D60 Precast Concrete Piles	m'	10400	IDR 1,061,000	Rp11,034,400,000
2	D600 Precast Concrete Pile Piling	m'	10400	IDR 329,000	Rp3,421,600,000
3	Bore Pile D120	m'	480	IDR 7,900,000	Rp3,792,000,000
4	Static Pole Testing	point	90	IDR 6,062,595	Rp545,633,550
5	Dynamic Pole Testing	point	90	IDR 17,244,030	Rp1,551,962,689
	PRICE AMOUNT		**Rp20,345,596,239**		

Table 1.2 Recapitulation of Foundation Work Costs Bore Pile D-80

No	WORK ITEMS	Sat.	Alternative 1 (BP D-80)		
			Volume	Unit Price	Price Amount
1	Bore Pile D80	m'	3600	IDR 4,890,492	Rp17,605,772,683
2	Static Pole Testing	point	90	IDR 6,062,595	Rp545,633,550
3	Dynamic Pole Testing	point	90	IDR 17,244,030	Rp1,551,962,689
	PRICE AMOUNT		**Rp19,703,368,922**		

Table 1.3 Recapitulation of Foundation Work Costs Bore Pile D-100

No	WORK ITEMS	Sat.	Alternative 2 (BP D-100)		
			Volume	Unit Price	Price Amount
1	Bore Pile D100	m'	3000	IDR 5,260,406	Rp15,781,218,062
2	Static Pole Testing	point	75	IDR 6,062,595	Rp454,694,625
3	Dynamic Pole Testing	point	75	IDR 17,244,030	Rp1,293,302,241
	PRICE AMOUNT		**Rp17,529,214,928**		

Table 1.4 Recapitulation of Bore Pile Foundation Work Cost d-120

No	WORK ITEMS	Sat.	Alternative 3 (BP D-120)		
			Volume	Unit Price	Price Amount
1	Bore Pile D1200	m'	2400	IDR 5,712,424	Rp13,709,816,732
2	Static Pole Testing	point	60	IDR 6,062,595	Rp363,755,700
3	Dynamic Pole Testing	point	60	IDR 17,244,030	Rp1,034,641,793
	PRICE AMOUNT		**Rp15,108,214,225**		

Table 1.5 Recapitulation of Square Pile Foundation Work Cost dia 45 cm x 45 cm

No	WORK ITEMS	Sat.	Alternative 4 (TP Square dia 45x45		
			Volume	Unit Price	Price Amount
1	Procurement of Square Piles dia 48 x 45	m'	4800	IDR 1,192,594	Rp5,724,449,280
2	Square Pole Hoisting dia 45 x 45	m'	4800	IDR 285,394	Rp1,369,890,651
3	Static Pole Testing	point	120	IDR 6,062,595	Rp727,511,400
4	Dynamic Pole Testing	point	120	IDR 17,244,030	Rp2,069,283,586
	PRICE AMOUNT			**Rp9,891,134,917**	

Work Time Analysis

After evaluating the cost of work for each alternative foundation, then an evaluation of the time of foundation work is carried out to see how long the duration is needed in the work of each alternative foundation offered.

Table 1.6 Recapitulation of the Time of Foundation Work for Each Foundation Alternative

WORK ITEMS	Time
	Day
Bore Pile D-80	268
Bore Pile D-100	224
Bore Pile D-120	179
Square Pile dia 45 x 45	170

2. Deck Slab Work

Deck Slab Work Unit Price Analysis

At this stage, the cost of deck slab work is determined, by the cantilever support method (hanging iron) and the cantilever elbow support method. The unit price used is sourced from the Project RAB and the Market Unit Price of East Java Province in 2022.

Table 1.7 Unit Price per Span Method *Support* Cantilever (Hanger Iron)

NO		DESCRIPTION	HANGER IRON METHOD			
			SAT.	VOLUME	SNACK PRICE	PRICE
I		**MATERIAL**				
	a	Beton Ready Mix K-350	m3	42.56	IDR 765,000	IDR 32,561,154
	b	Reinforced Iron	kg	9,209.75	IDR 10,500	IDR 96,702,334
	c	Tenolith (t = 10 mm)	m2	53.58	IDR 121,528	IDR 6,511,750
	d	Hollow Iron (40x60x2mm)	kg	1,068.32	IDR 19,000	IDR 20,298,080
	e	Iron Hanger (Double UNP)	kg	1,001.00	IDR 19,000	IDR 19,019,000
	f	Iron Hanging Pedestal	kg	627.33	IDR 10,500	IDR 6,586,933
II		**TOOL**				
	a	Concrete Pump	day	0.50	IDR 3,500,000	IDR 1,750,000
	b	Concrete Vibrator		-	IDR 0	IDR 0
	c	Tools		-	IDR 0	IDR 0
III		**POWER**				
	a	Wages for Ironing	kg	9,209.75	IDR 1,025	IDR 9,439,990
	b	Formwork Installation Wages	m2	53.58	IDR 210	IDR 11,252
	c	Foundry Wages	m3	42.56	IDR 100,000	IDR 4,256,360

PRICE AMOUNT	**Rp197,136,854**

Table 1.10 Unit Price per Span Method Support Siku Kantilever

NO		DESCRIPTION	SUPPORT SIKU CANTILEVER METHOD			
			SAT.	**VOLUME**	**SNACK PRICE**	**PRICE**
I		**MATERIAL**				
	a	Beton Ready Mix K-350	m3	42.56	IDR 765,000	IDR 32,561,154
	b	Reinforced Iron	kg	9,209.75	IDR 10,500	IDR 96,702,334
	c	Tenolith (t = 10 mm)	m2	53.58	IDR 121,528	IDR 6,511,750
	d	Hollow Iron (40x60x2mm)	kg	1,373.70	IDR 19,000	IDR 26,100,332
	and	Iron Hanger (Double UNP)	kg	-	IDR 0	IDR 0
	f	Iron Hanging Pedestal	kg	-	IDR 0	IDR 0
II		**TOOL**				
	a	Concrete Pump	day	0.50	IDR 3,500,000	IDR 1,750,000
	b	Concrete Vibrator		-		IDR 0
	c	Tools		-		IDR 0
III		**POWER**				
	a	Wages for Ironing	kg	9,209.75	IDR 1,025	IDR 9,439,990
	b	Formwork Installation Wages	m2	53.58	IDR 210	IDR 11,252
	c	Foundry Wages	m3	42.56	IDR 100,000	IDR 4,256,360
		PRICE AMOUNT				**IDR 177,333,173**

Comparative Analysis Evaluation of Work Methods

At this stage, a comparison of the cast results of each deck slab work method is carried out
.

Figure 1.2 Quality of Cast Results Method Support Cantilever (Hanger Iron)

Figure 1.3 Quality of Cast Results Method Support Siku Kantilever

Based on Figure 1.3 and Figure 1.4, the advantages and weaknesses of the cast results can be found from both work methods. The quality comparison of the work method is as follows:

Cantilever Support Method	Method Siku Support Siku kantilever
– The flatness of the top cast concrete deck slab is better but can still be improved	– The flatness of the top cast deck slab is flatter. – Straight grooving results

– The grooving results cannot be straight and neat because they are blocked by the hanger iron

Development Stage

After analyzing each alternative, the next step is to determine the alternative to be chosen. At this stage, the AHP (Analytical Hierarchy Process) hierarchy model method is used in questionnaire decision-making. 8 experts are experts in the field of construction. There are 4 criteria in the selection of alternatives, namely structural strength, time, weight, and workability The following is the output of the calculation using the help of Expert Choice software.

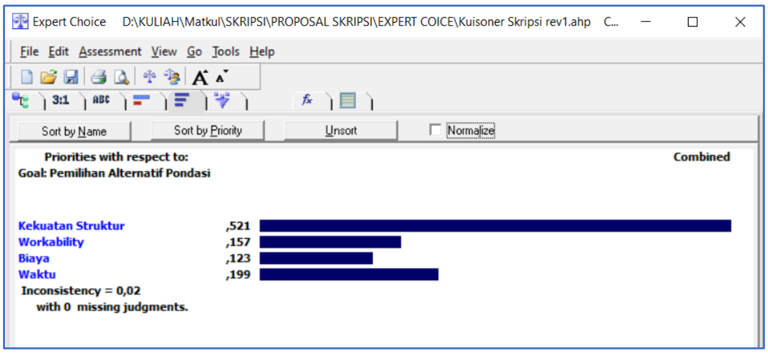

Figure 1.4 *Output* Calculation of Criteria

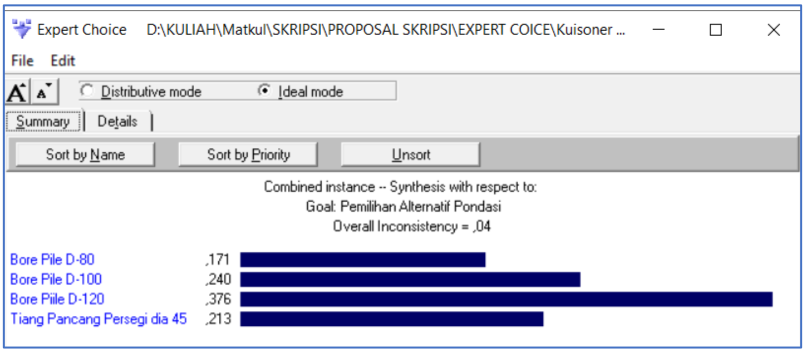

Figure 1.5 *Output* Alternative Calculations

From the results of the alternative calculation, the alternative foundation chosen is the d-120 bore pile foundation with a weight of 37%. These alternatives are superior to other alternatives, namely 23% d-100 ¬bore pile foundation, 24% d-100 bore pile foundation, 21% d-45 x 45 square pile foundation, and ¬17% d-80 bore pile foundation with an inconsistency value of 4% so that it still qualifies.

Presentation Stage

After going through the stages of Value Engineering analysis, the following results were obtained:

1. Existing Fees

The existing cost of deck slab work with the cantilever support method (hanging iron) is IDR 197,136,854. For foundation work, use d-60 pile foundation and d-120 bore pile foundation amounting to Rp 20,345,596,239

2. Alternatives Offered
   Based on the results of cost calculations, strength calculations, and questionnaire analysis using the help of Expert Choice software, the chosen alternative is the use of the cantilever elbow support method and the d-120 bore pile foundation. For deck slab work, savings of Rp 19,803,681 or 11% were obtained. For foundation work, savings of Rp 5,237,382,014 or 26% were obtained
3. Cost Comparison
   Before the Value Engineering analysis, the total project cost was IDR 157,155,343,159. After the Value Engineering analysis, the total project cost was IDR 124,174,758,247, so a savings of IDR 15,108,214,225, or 10% of the total project cost, was obtained.

Conclusion

Based on the Value Engineering analysis that has been carried out on the JPL 64 Km 38 + 897 Replacement Fly Over Construction Project Surabaya – Solo, the following conclusions can be drawn: (1) In this study, the types of work items selected for Value Engineering analysis are deck slab work and foundation work. (2) The alternative chosen for foundation work is the D-120 Bore Pile Foundation.(3) The most effective method of working on deck slab work is the deck work method of slab using cantilever elbows. (4) From the Value Engineering analysis carried out, cost savings of Rp 15,108,214,225 or 10% of the total cost of the JPL 64 Km 38 + 897 Fly Over Construction Project Crossing Surabaya – Solo.

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