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Implementation of Value Engineering in Bandung Islamic University Hospital Building Construction

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Abstract: Infrastructure development in Indonesia has increased sharply every year. Construction projects are starting to appear at a fairly high frequency in each region. However, in the process of project development, the quality, time, and cost aspects are not always optimal. Therefore, Value Engineering analysis is needed to get optimal results. This Value Engineering analysis is able to identify components that can be saved and determine alternatives to replace these components without reducing the quality or quality of work. The case study in this research is the Bandung Islamic University Hospital Construction Project. The Value Engineering analysis carried out on this project is a change in the work of the upper structure, such as slab, column and beam from conventional to precast concrete. In addition to Value Engineering analysis, this research also analyzed greenhouse gas emissions using Life Cycle Assessment analysis. The results showed savings of Rp 3,180,685,659.81 or 8.19% of the initial project cost. Meanwhile, the existing greenhouse gas emissions amounted to 9556.01 kgCO2e and for alternative work amounted to 72896.49 kgCO2e.

Keywords: Life Cycle Assessment, Precast Concrete, Value Engineering

Introduction

Infrastructure development in Indonesia has increased sharply every year. This is caused by people who need facilities to develop their products and services (Kurniawati et al., 2018). With the development of the times, innovations are increasingly emerging so that the community's need for supporting facilities has become unstoppable. Some of these facilities include hospitals, police stations, houses, and even entertainment venues. Construction projects began to appear at a high frequency in each region in order to maintain the welfare of the community. Especially in big cities such as Bandung, Jakarta, Surabaya, and so on.

Every construction project has important aspects including cost, quality, and time. Those three aspects are the description of a project. However, not all projects have o(Wright & Davidson, 2020)ptimal time, quality, and cost aspects. These problems include inefficient use of materials, unskilled human resources, and inappropriate project implementation times that have the potential to cause waste of construction costs (Gede et al., 2018). Problems in the aspects of cost, quality, and time are caused by poor project management (Priyo et al., 2008). These problems must be addressed immediately at the beginning of the project in order to allow for changes in both materials and human resources. Therefore, a Value Engineering (VE) analysis is required(Chandrupatla & Belegundu, 2021).

Value Engineering is an organized effort to analyze a problem that aims to achieve the desired functions at total cost and optimal results (Dell'Isola, 1975). This VE analysis is able to identify components that can be saved and determine alternatives to replace these components without reducing the quality or quality of work. The application of VE analysis is expected to obtain alternatives to solve problems that will be used by project stakeholders so as to reduce the cost of building the UNISBA Hospital building(Rice et al., 2023).

Methodology

This research takes a case study on the UNISBA Hospital Building construction project. The project is located at Jalan Raya Nagreg, Citaman Village, Nagreg District, Bandung Regency. This project is a self-managed project of the Bandung Islamic University Hospital Foundation with a contract value of Rp. 82,660,691,334.28.

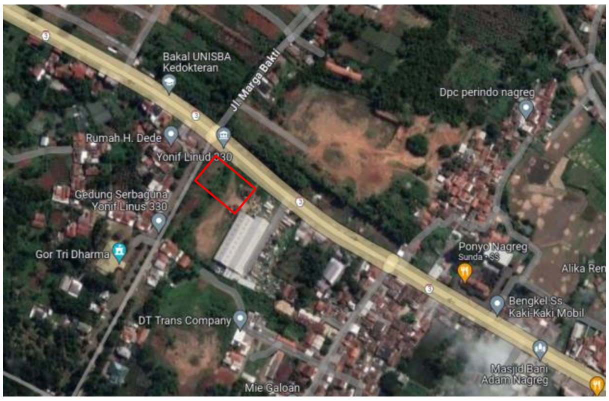

Figure 1.1 Location of UNISBA Hospital Building Construction

Value Engineering Analysis used in this research are divided by five main stages, according to (SAVE, 2007), there are(Goswami, 2022):

1. Information stage, is the first step of the Value Engineering Analysis which purpose is to collect all necessary data and information needed for this research. In this stage, cost breakdown structure and pareto distribution law are used to find the component that to be analyzed using Value Engineering.
2. Function analysis stage, is a stage to find the basic function of each component. This stage is the most important of the Value Engineering Analysis.
3. Creative stage, is a stage which purpose is to find the alternatives of the existing component. This alternative must be more efficient and didn't reduce the value of the existing component.
4. Analysis stage, is a stage to analyze the available alternatives and eliminate them to find the most efficient alternative.
5. Presentation stage, is a stage to report the result of the analysis to the stakeholders.

Life Cycle Assessment (LCA) is used to determine the greenhouse gas (GHG) emissions resulting from concrete work. GHGs can take the form of Carbon Dioxide (CO_2), Methane (CH_4), and other gases. To calculate GHG emissions, it can be done by multiplying the emission factor of each material. However, the GHG emission analysis used in this study is the concrete work in the field using heavy equipment(Kamphuis, 2020). This is because in this study only changes the method of concrete work in the field and does not change the composition of the concrete used. The tools used in the existing work are concrete pump, mixer truck, and vibrator. While the tools used in alternative work are vibrators, mixer trucks, and roller cranes in erection work(Rao, 2019).

Result and Discussion

Information Stage

The construction of the UNISBA Hospital Building has a land area of ± 4020 m2 and a building area of ± 19392 m2. The project has a contract value of Rp. 82,660,691,334.28 with a building height of ± 34.25m. The first step in this analysis is to perform a Pareto Distribution Law analysis on the work components(Gibson, 2019).

Table 1: Pareto Distribution Law Analysis Results

No	Type of Work	Cost (Rp)	Cost Percentage (%)	Cumulative Percentage (%)
1	Structural work	41.556.848.998,57	44.20	44.20
2	Architectural work	35.100.756.762.29	37.34	81.54
3	Electrical work	8.850.551.283,67	9.41	90.96
4	Plumbing work	7.869.739.426,90	8.37	99.33
5	Preparatory work	632.518.420,00	0.67	100
	Total	**94.010.414.891,43**		

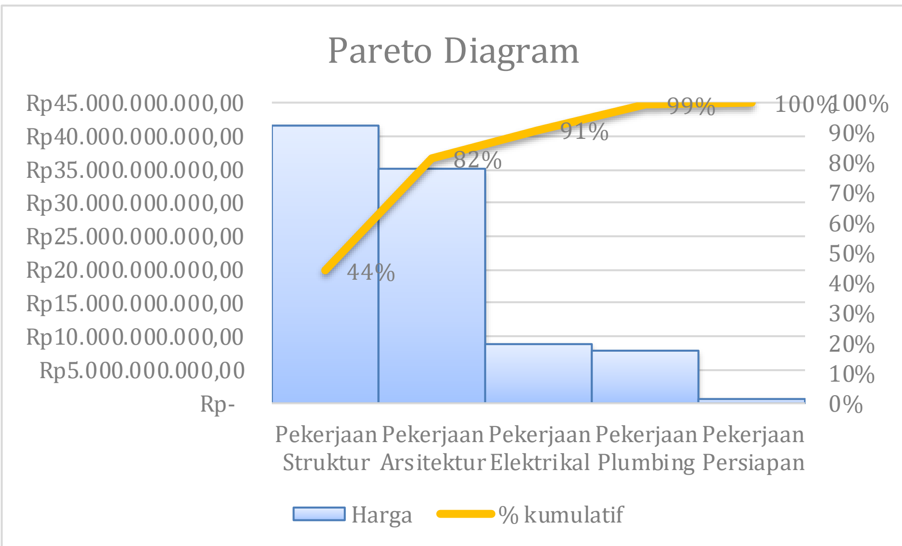

Figure 1. Graph and Diagram of Pareto Distribution Law

Based on Pareto's Law analysis, the work components to be analyzed are plates, columns, and beams because they are the structural work components with the highest costs(Mitcham, 2022).

Function Analysis Stage

This stage serves to find out the basic functions of each work component to be analyzed. The method used at this stage is the FAST diagram (Function Analysis System Diagram). FAST diagrams are used to find out functions in more detail, both primary and secondary functions(Sinnott & Towler, 2019).

Creative Stage

At this stage, alternative ideas were developed to replace existing work components with new components that were more cost-effective without reducing the quality of the existing work. The chosen alternative was to replace conventional concrete work with precast concrete for column beam and slab work(Bolz, 2019).

Analysis Stage

The Analysis stage is a stage carried out with the aim of evaluating each alternative obtained from the previous stage. The analysis is carried out in the hope of knowing whether the alternative work is feasible to be applied as a replacement for existing components or not. The analysis stage in this research is based on SNI 7832-2017, Unit Price Analysis of On-site Precast Concrete Work for Building Construction. The SNI contains unit price of work for on-site precast concrete work. SNI 7832-2017 is a revision of SNI 7832-2012 where in SNI 7832-2017, the erection work can reach 24 floors while SNI 7832-2012 is only up to five floors. Below are tables recapitulating the unit prices of the existing work of plates, columns, and beams(Breneman et al., 2022).

Table 2: Recapitulation of Unit Price of Existing Slab Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
1	Concrete grade K - 350	3100.358	m^3	1,162,200.00	3,603,236,067.60
2	BJTS-40 Reinforcement	324206	kg	16,853.00	5,463,857,063.76
3	Formwork for floor slab	20586	m^2	366,300.00	7,540,811,653.32
				Total	**16,607,904,784.68**

Table 3: Recapitulation of Unit Price of Existing Column Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
1	Concrete grade K - 425	1521.76	m^3	1,162,200.00	3,603,236,067.60
2	BJTS-40 Reinforcement	329879	kg	16,853.00	5,463,857,063.76
3	Formwork for floor slab	7808.8	m^2	366,300.00	7,540,811,653.32
				Total	**9,977,172,811.86**

Table 4: Recapitulation of Unit Price of Existing Beam Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)

1	Concrete grade K - 350	2135	m^3	1,162,200.00	3,603,236,067.60
2	BJTS-40 Reinforcement	343889	kg	16,853.00	5,463,857,063.76
3	Formwork for floor slab	12395	m^2	366,300.00	7,540,811,653.32
				Total	**12,272,234,072.72**

After obtaining the unit price of the existing work of plates, columns, and beams, the next step is to make alternative work unit prices of the three work components. The making of this alternative unit price is guided by SNI-7832 2017(Cross, 2021).

Table 5: Recapitulation of Unit Price of Alternative Slab Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
1	Concrete grade K - 350	3100	m3	2,125,500.00	6,589,810,929.00
2	Wage for pouring/ spreading concrete	3100	Pcs	77,000.00	238,727,566.00
3	Reinforcement bar	324206	kg	16,800.00	5,446,674,103.79
4	Making formwork	4117.	m2	476,600.00	1,962,299,117.65
5	Uninstall formwork	780	Pcs	9,200.00	7,176,000.00
6	Erection	780	Pcs	388,800.00	303,264,000.00
				Total	**14,547,951,716.44**

Table 6: Recapitulation of Unit Price of Alternative Column Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
1	Concrete grade K - 350	1521.76	m3	2,125,500.00	3,234,500,880.00
2	Wage for pouring/ spreading concrete	1521.76	m3	71,400.00	108,653,664.00
3	Reinforcement bar	329879	kg	16,800.00	5,541,981,643.30
4	Making formwork	780	m2	72,800.00	56,848,064.00
5	Uninstall formwork	506	Pcs	12,000.00	6,072,000.00
6	Erection	506	Pcs	466,600.00	236,099,600.00
7	Joint	506	Pcs	130,048.60	65,804,591.60
				Total	**9,249,960,442.90**

Table 7: Recapitulation of Unit Price of Alternative Beam Work

No	Type of Work	Volume	Unit	Unit Price (Rp)	Total Price (Rp)
1	Concrete grade K - 350	2135.166	m3	2,125,500.00	4,538,295,333.00

2	Wage for pouring/ spreading concrete	2135.166	m3	79,100.00	168,891,630.60
3	Reinforcement bar	344210	kg	16,800.00	5,782,728,000.00
4	Making formwork	12395.83	m2	59,100.00	732,593,553.00
5	Uninstall formwork	1055	Pcs	14,800.00	15,614,000.00
6	Erection	1055	Pcs	361,400.00	381,277,000.00
7	Joint	1055	m3	250,900.79	264,700,333.45
				Total	**11,884,099,850.05**

After obtained the calculation results of existing and alternative work, the next step is to create a cost/worth table. The cost column is filled with the cost of the existing work, while the worth column is filled with the cost of the alternative work(Pan & Zhang, 2021).

Table 8: Recapitulation of Unit Price of Alternative Beam Work

No	Type of Work	Function		Cost	Worth
		Verb	Noun	Rp	Rp
1	Slab	Receive	Load	16,607,904,784	14,547,951,716
2	Column	Forward	Load	9,977,172,811	9,249,960,442
3	Beam	Forward	Load	12,272,234,072	11,884,099,850
				Ratio Cost/Worth	**1.09**

Based on the cost/worth ratio that has been obtained, it can be seen that the alternative is feasible because the cost/worth value is more than 1.

Greenhouse Gas Emission Analysis

The analysis of greenhouse gas (GHG) emissions used in this study is the emissions released in concrete work in the field using heavy equipment. This analysis requires tool usage time and emission factor. Usage time used in this research is based on survey. Meanwhile emission factor is gained from EcoInvent 3.3 (2014)(Ramos et al., 2020).

Table 9: Recapitulation of Usage Time of Each Equipment

No	**Type of Equipment**	**Usage Time (Hr)**
1	Concrete pump	140,78
2	Vibrator	140,78
3	Crawler crane	390,25
4	Mixer truck	140,78

Table 10: Recapitulation of GHG Produced per 1 Hour

No	**Type of Equipment**	**GHG Produced (kgCO2e)**
1	Concrete pump	64,948

2	Vibrator	2,931
3	Crawler crane	185,737
4	Mixer truck	16,003

Table 11: Recapitulation of GHG Produced in Existing Work

No	Type of Equipment	Usage Time	Emission Factor ($kgCO_{2e}$/hr)	Emission Produced ($kgCO_{2e}$)
1	Concrete pump	140,78	64,948	9143,38
2	Vibrator	140,78	2,931	412,63
3	Mixer truck	140,78	16,003	2252,902
			Total	**11808,908**

Table 12: Recapitulation of GHG Produced in Alternative Work

No	Type of Equipment	Usage Time	Emission Factor ($kgCO_{2e}$/hr)	Emission Produced ($kgCO_{2e}$)
1	Vibrator	140,78	2,931	412,63
2	Crawler crane	390,25	185,737	72483,86
3	Mixer truck	140,78	16,003	2252,902
			Total	**75149,393**

Presentation Stage

The presentation phase of the conducted VE study is described as follows:

1. Existing condition

The cost of existing column work is Rp 9,977,172,811.86; existing beam work is Rp 12,272,234,072.72; and for existing slab work is Rp 16,607,904,784.68.

2. Alternative condition

Based on the analysis that has been carried out, namely VE and LCA analysis, the recommended alternative design is to change conventional concrete work to precast concrete for slab, column, and beam work. The alternative can save costs of Rp 3,180,685,659.81 or about 8.19% of the existing costs(Punmiya & Choe, 2019).

Table 13: Recapitulation of Cost Savings

No	Type of Work	Existing (Rp)	Alternative (Rp)
1	Slab	16,607,904,784.68	14,547,951,716.44
2	Column	9,977,172,811.86	9,249,960,442.90
3	Beam	12,272,234,072.72	11,878,713,850.12
		Savings	**3,180,685,659.81**
		% Savings	**8.19%**

Table 14: Recapitulation of GHG Emissions

	Existing ($kgCO_{2e}$)	Alternative ($kgCO_{2e}$)	Difference ($kgCO_{2e}$)
Emission	9556,01	72896,49	63340,48

Conclusion

Based on the results of research and data analysis that has been carried out on the Bandung Islamic University Hospital Building Construction Project (UNISBA), the following conclusions can be drawn:

1. Based on the available data, a pareto analysis is carried out so that the work components that will be analyzed using the Value Engineering method are plate, column, and beam work.
2. After the value engineering analysis, we obtained project cost savings for structural work of Rp 3,180,685,659.81 or 8.19% of the initial project cost. This savings can be obtained from the difference in formwork costs required between existing and alternative work. In the existing work, formwork is only used twice. Whereas in the alternative work, formwork is used ten to twelve times. So the cost required in alternative work is less.
3. In the LCA analysis, the focused work is only concrete work in the field that pays more attention to the heavy equipment used. After the analysis, the amount of greenhouse gas emissions for the existing work was 9556.01 kgCO2e while the amount of greenhouse gas emissions for alternative work was 72896.49 kgCO2e. From these results, it can be seen that greenhouse gas emissions released from alternative work are greater. This is because in the alternative work there is a lot of erection work where the use of tower cranes is the highest source of greenhouse gas emissions.

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