VALUE ENGINEERING ANALYSIS OF BUILDING UPPER STRUCTURE FOR COST EFFICIENCY

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Abstract: Value engineering is the process of identifying alternatives that can provide the same functionality at the same or better level as the original plan while reducing costs and increasing benefits. The research was conducted at the Phase 3 development project of the Islamic University of Islam Malang) because there was a difference between the initial contract fee of Rp. 28,102,142,530 and the change order contract of Rp 20,875,433,588 in upper structure. The aims of the research are: (1) to describe the Development Project of the Islamic University of Malang Islamic Hospital Phase 3; (2) Identifying work items on the upper structure at the information stage; (3) Proposing alternative work items for the upper structure to be analysed by value engineering at the creative stage; (4) Analysing alternative work on the upper structure at the analysis stage; (5) Recommend alternative top structure work items through simulation at the recommendation stage; (6) Describe the level of differences in the structure budget plan for the project and the structure budget plan for value engineering. The research design uses descriptive research design and comparative methods using primary primers such as working drawings, work plans and requirements, and budget plans. The results of the research are: (1) The Islamic University of Malang Islamic Hospital Development Project Stage has a structured budget plan of Rp. 20,875,433,588.49; (2) Alternative work items are given, namely 40/70 for main beams, 30/50 for joists, and floor slabs; (3) The alternative proposed is main beam 35/70 diameter of 19 reinforcement, main beam 40/70 diameter of 16 reinforcement, joist beam 25/50 diameter of 19 reinforcement, joist beam 30/50 diameter of 16 reinforcement, HCS floor plate, flat floor plate palace; (4) Analysis of work alternatives shows that the cost of a 35/70 beam with 19 reinforcement diameter is IDR 3,580,322,171, while a 40/70 beam with 16 reinforcement diameter is IDR 3,410,727,402. Beam 25/50 diameter of reinforcement 19 is Rp. 3,505,187,178, while beam 30/50 diameter of reinforcement 16 is Rp. 3,403,995,232. The HCS precast plate is Rp. 4,647,951,520, while the non-palace plate is Rp. 5,431,891,666; (5) The selected alternative and recommended to the owner are main beam 40/70 diameter of reinforcement 16 with a saving of 16.4%, joist beams of 30/50 diameter of reinforcement 16 with a saving of 12%, and HCS precast plate with a saving of 3%; (6) There is no significant difference between the project budget plan and the value engineering budget plan.

Keywords: Upper structure, Value Engineering, Beams, Slabs

1. INTRODUCTION

The process of realizing a project is determined by 3 limitations, namely budget, time, and quality that must be met (Suharto in Baihaqi, 2020). Efficiency is a measure of the use of resources to perform a process. The cheaper and faster the processing of a process, the more efficient the resources used (Sedarmayanti in Mahardita, 2017). Efficiency can be obtained one way by using vacuum engineering applications, namely the process of identifying alternative solutions that can provide the same function at the same level or better than the original plan while reducing costs and increasing benefits (Sanchez et al, 2018).\Based on the PUPR Ministerial Regulation concerning Technical Guidelines for the Construction of State Buildings (2018), buildings above 8 floors are required to organize a value engineering work unit package. The research was conducted at the Phase 3 development project of the Islamic University of Islam Malang because there was a difference between the initial contract fee of Rp. 28,102,142,530 and the change order contract of Rp. According to Maulana (2016) the decline in contract value is caused by a less thorough plan design. The author wants to know from these conditions whether efficiency can still be carried out by using value engineering analysis. The author chooses superstructure work due to delays in the processing process. Problems in carrying out work that cause delays include management inefficiencies so that value engineering can be applied to obtain more efficient costs by providing alternatives to the initial design (Medonca, 2015)

2. METHOD

The method used is descriptive research with a comparative research method that aims to make savings on the project budget in accordance with the work steps of value engineering and to find out the significance of the difference in costs between before and after value engineering is carried out. Descriptive research serves to describe or give an overview of the object under study through data or samples that have been collected as they are (Sugiyono, 2017). The design of this study describes the construction project of the Islamic University of Malang Islamic Hospital. Comparative research is research that compares the presence of one or more variables in two or more different samples (Sugiyono, 2017). The design of this study compares the RAB of superstructure work before and after value engineering analysis is carried out

The population in this project is the superstructure work on the Islamic University of Malang Islamic Hospital Development Project Phase 3. The sample in this project is the cost of the upper structure work items on the Islamic University of Malang Islamic Hospital Development Project Phase 3. In general, the number of samples required for excellent research results requires a minimum of 30 samples for research. Descriptive and comparative analysis research, so the sample to carry out the analysis test is 30 data (Hilmafitra, 2018).

Analysis of the research data on the structure of the upper structure according to the stages value engineering, namely the information stage, the creative stage, the analysis stage, the stage recommendations, and coupled with the t test using SPSS version 22 for windows to find out the difference in project costs and value engineering costs on the job upper structure (Tjakra, et al, 2016).

3. HASIL

3.1. Description of the Project for the Construction of the Islamic University of Malang Islamic Hospital Phase 3

1. Project Name : Construction of the Islamic University of Malang Islamic Hospital Building Phase 3
2. Procurement System : Tender – Lowest Price Post-Qualification
3. Owner : Islamic Hospital, Islamic University of Malang
4. Planning Consultant : Foundation Team of the Islamic University of Malang
5. Supervisory Consultant: Foundation Team of the Islamic University of Malang
6. Executing Contractor : PT. Dwi Ponggo Seto
7. Location : Jl. MT. Haryono 193 Malang
8. Project Cost : Rp. 57,300,000,000.00
9. Implementation Period: 1 March 2020 – 28 February 2021

3.2. Identification of Upper Structure Work Items in the Information Stage

Identification of work items on the upper structure using the breakdown cost model and analysis method to find work that is feasible to do value engineering.

3.2.1 Identification of Upper Structure Work Items Based on the Breakdown Cost Model

Table 1. Results of the Breakdown Cost of the Upper Structure Work Model

No.	Job Description	Total Price (Rp)	Total Job Price (Rp)	Percentage
1	Concrete Floor Plate t=12 cm concrete K-300	4,772,524,692.53	20,875,433,588.49	22.9%
2	K-300 concrete 40/70 beam	4,080,519,929.08	20,875,433,588.49	19.5%
3	K-300 concrete 30/50 beam	3,848,528,010.76	20,875,433,588.49	18.4%

3.2.2 Identification of Upper Structure Work Items Based on Functional Analysis

Table 2. Analysis of the Upper Structure Job Function

No	Job Items	Noun Function	Cost	Worth	C/W
			Rp.	Rp.	%
1	Main beam 40/70	Receive Load Upper Structure	4,080,493,062	3,671,735,396	1.265
2	Secondary beam 30/50	Receive Load Upper Structure	3,848,528,010	2,779,491,278	1.384
3	Floor plate	Mold Balok 40/70	3,740,179,581	3,236,939,736	1.61

3.3. Proposed Alternative Top Structure Work Items in the Creative Stage

Table 3. Proposed Upper Structure Work Alternatives

No.	Job Items	Alternative 1	Alternative 2
1	Beam 40/70	Beam 35/70	Beam 40/70
	Iron D19	Iron D19	Iron D16
2	Beam 30/50	Beam 25/50	Beam 30/50
	Iron D19	Iron D19	Iron D16
3	Plate t = 12 cm	Precast t = 12 cm	Plate dak Keraton
	Iron D12	PC-Wire 55 mm dan 7mm	type L-93

3.4. Analysis of the Proposed Alternative Top Structure Work Items at Stage Analysis

Alternative analysis uses profit and loss analysis and life cycle cost to analyze the alternatives that have been proposed.

3.4.1 Analysis of Proposed Alternative Work Items on the Top Structure Based on Advantages and Disadvantages

Table 4. Analysis of Advantages and Disadvantages of Alternative Superstructure Works

No	Items Job	Alternative	Advantage	Disadvantage
1	Beam 40/70 Iron D19	Beam 35/70 Iron D19	Smaller volume of concrete, No need to change reinforcement	The nominal strength of the beam is lower, the risk of the beam b/h ratio is too high
		Beam 40/70 Iron D16	Rebar bending is easier, reinforcement transportation to site is easier	Need to change the design of the reinforcement diameter, affecting the BBS
2	Beam 30/50 Iron D19	Beam 25/50 Iron D19	Smaller volume of concrete, Reducing the volume of use of formwork	The nominal strength of the beam is lower, the risk of the beam b/h ratio is too high
		Beam 30/50 Iron D16	Rebar volume is smaller, Rebar bending is easier	Need to change the design of the reinforcement diameter, affecting the BBS
3	Plate t = 12 cm Iron D12	Precast Plate	Fast turnaround time, can be prefabricated and installed on site	The work is very dependent on heavy equipment, special handling is required for installation
		Floor Plate Keraton	Reducing the weight that needs to be supported by the structure, Less use of formwork because there is no need for a large number of formwork molds	The nominal strength of the beam is lower, the risk of the beam b/h ratio is too high

Table 5. Calculation of Preliminary Design Costs and Alternative Superstructure Works

No	Job	Volume	Unit	Unit Price (Rp.)	Total Price (Rp.)
		Initial Design			
1	Beam 40/70 Iron D19	911,35	m^3	6,135,877.87	5,591,932,305.00
		Alternative 1			

No	Job	Volume	Unit	Unit Price (Rp.)	Total Price (Rp.)
	Beam 35/70 Iron D19	797,43	m3	6,768,257.38	5,397,211,485.00
			Alternative 2		
	Beam 40/70 Iron D16	991,35	m3	5,743,749.52	5,234,566,133.00
			Initial Design		
	Beam 30/50 Iron D19	891,74	m3	6,030,658.35	5,377,779,280.00
			Alternative 1		
2	Beam 25/50 Iron D19	743,12	m3	6,638,724.82	4,933,369,191.00
			Alternative 2		
	Beam 30/50 Iron D16	891,74	m3	5,524,366.053	4,926,298,184.00
			Initial Design		
	Floor Plate t = 12	1.185,14	m3	4,315,751.24	4,772,524,692.53
			Alternative 1		
3	HCS Precast	1.185,14	m3	3,921,858.62	4,647,951,520.96
			Alternative 2		
	Dak Keraton	1.185,14	m3	4,583,333.33	5,431,891,666.67

3.4.2 Analysis of Alternative Work Items Proposed Upper Structure Based on Life Cycle Cost

Table 6. Life cycle cost analysis of alternative superstructure works

No	Job Items	Total *Life Cycle Cost*
1	**2**	**3**
1	Beam 40/70 Iron D19	1,006,547,814.86
	Beam 35/70 Iron D19	971,498,067.27
	Beam 40/70 Iron D16	942,221,903.94
2	Beam 30/50 Iron D19	968,000,270.32
	Beam 25/50 Iron D19	888,006,454.39
	Beam 30/50 Iron D16	886,733,673.11
1	**3**	**3**
3	Floor Plate t = 12	859,054,444.66
	HCS Precast	836,631,273.77
	Dak Keraton	977,740,500.00

3.5. Alternative Recommendations for Upper Structure Work Items at Stage Recommendation

Table 7. Alternative recommendations for superstructure work

No.	Job Items	Choosen Alternative	Saving Rp.	Percentage %
1	Beam 40/70 Iron D19	Beam 40/70 Iron D16	357,366,171.8	6,4%
2	Beam 30/50 Iron D19	Beam 30/50 Iron D16	451,481,095.6	8,4%
3	Floor Plate t = 12	Pracetak HCS	124,573,171.57	3%

3.6. Description of the Different Levels of the Upper Structure Cost Budget Plan Preliminary Budget and Planned Cost Structure of Value Engineering

Table 8. Independent T Test Results

Name	t	Df	Sig. (2 tailed
RAB Proyek - RAB *VE*	0,231	58	,818

4. DISCUSSION

4.1. Description of the Islamic University of Malang Islamic Hospital Development Project Phase 3

Phase 3 of the Islamic University of Malang Construction Project with the implementing contractor PT. Dwi Ponggo Seto on Jalan MT. Haryono No. 139, Dinoyo, Kec. Lowokwaru, Malang City, East Java with a total project cost of Rp. 57,300,000,000.00. This step is in accordance with Latief (2014) regarding providing a project description by collecting information directly related to the project.

4.2. Identification of Upper Structure Work Items in the Information Stage

Identification of work items on the upper structure using the breakdown cost model and analysis method to find work that is feasible to do value engineering. This step is in accordance with Akhmad's research (2018) identification of work items on the upper structure using the breakdown cost model method and function analysis.

4.2.1. Identification of Upper Structure Work Items Based on the Breakdown Cost Model table

Based on the identification of the breakdown cost model, the work item with the highest cost was obtained, namely the work of Concrete Floor Plate t = 12 cm K-300 concretes with a percentage of 22.9%, 40/70 main beam K-300 concrete with a percentage of 19.5%, 30 child beams /50 concrete K-300 with a percentage of 18.4%. This step is in accordance with Rahman's research (2016) regarding cost identification using the breakdown cost model in order to obtain alternative work items through the highest cost percentage

4.2.2. Identification of Upper Structure Work Items Based on Functional Analysis

Based on the analysis results in table 4.2 the C/W value for 40/70 beam work is 1.265%, table 4.3 the C/W value for 30/50 beam work is 1.384%, and table 4.4 the C/W value for floor slab work is 1 .61%. The value of C/W for each item of work with a dominant cost result in > 1, therefore the work is feasible for value engineering analysis. This step is in accordance with Mendonca's research (2015) regarding functional analysis by looking for a cost / worth value > 1 which is feasible for value engineering analysis.

4.3. Proposed Alternative Top Structure Work Items in the Creative Stage

The alternative proposed for the work of 40/70 beam D19 is replaced by 35/70 beam D19 and 40/70 beam D16. The alternative proposed for the work of 30/50 beam D19 is replaced by 25/50 beam D19 and 30/50 beam D16. The alternative proposed for the t = 12 cm plate D12 iron is replaced by the precast t = 12 cm Pc-Wire 5 mm and 7 mm and the non-keratony plate type L-93. This step is in accordance with Soares' research, (2017) which provides an alternative job by changing the simplification of dimensions or modification while maintaining the main function of the object.

4.4. Analysis of the proposed alternative work items on the upper structure in the analysis stage

Alternative analysis uses profit and loss analysis and life cycle cost to analyze the alternatives that have been proposed. This step is in accordance with Berawi (2014) regarding alternative analysis using profit and loss and life cycle cost analysis methods.

4.4.1. Analysis of Alternative Work Items Proposed Upper Structure based on Advantages and Disadvantages

Beam 35/70 diameter of reinforcement 19 has the advantage of smaller concrete volume thereby reducing the use of formwork. Beam 40/70 diameter 16 reinforcement has smaller reinforcement so iron weight is lighter which makes the price cheaper than beam 40/70 diameter 19 reinforcement and back 35/70 diameter 19 reinforcement. Beam 30/50 diameter 16 reinforcement volume is smaller so that bending reinforcement is easier besides that the transportation of reinforcement to the site is easier. Precast plates have the advantage of faster processing time because they are fabricated first and directly installed on site. The use of formwork and precast wood plates is also less than conventional plates and palace plates. The cost of the main beam 40/70 diameter of 19 reinforcement IDR 5,591,932,305.00, beam 35/70 diameter of 19 reinforcement IDR 5,397,211,485.00, and beam 40/70 diameter of 16 reinforcement IDR 5,234,566,133.00. The cost of 30/50 beams with 19 reinforcement diameter is IDR 5,377,779,280.00, 25/50 beam with 19 reinforcement diameter is IDR 4,933,369,191.00, and 30/50 beam 16 diameter IDR 4,926,298,184.00. The cost of conventional floor plates t = 12 Rp. 4,772,524,692, HCS floor plates Rp. 4,647,951,520, and non-palace plates Rp. 5,431,891,666. This step is in accordance with Amidarmo (2017) regarding the calculation of initial and alternative design costs using a comparison of advantages, disadvantages, and calculation of total costs.

4.4.2. Analysis of Alternative Work Items Proposed Upper Structure Based on Life Cycle Cost

The life cycle cost of main beam 40/70 diameter of 19 reinforcement Rp. 1,006,547,814.86, beam 35/70 diameter of 19 reinforcement Rp. 971,498,067.27, and beam 40/70 diameter of 16 reinforcement Rp. 942,221,903.94. The cost of 30/50 beams with 19 reinforcement diameter are IDR 968,000,270.32, 25/50 beam with 19 reinforcement diameter is IDR 888,006,454.39, and 30/50 beam with 16 reinforcement diameter is IDR 886,733,673.11. The cost of conventional floor plates t = 12 Rp. 859,054,444.66, HCS floor plates Rp. 836,631,273.77, and non-palace plates Rp. 977,740,500.00. This step is in accordance with Berawi (2014) regarding the total life cycle cost which uses initial, operational, maintenance, replacement material costs, residual value from the initial design and alternatives.

4.5. Recommendations for Alternative Upper Structure Work Items Through Simulation at the Recommendation Stage

The recommended alternative for 40/70 beam work is 40/70 beam with reinforcement diameter 16 with a saving of IDR 357,366,171.8 or 6.4% of the initial project cost. The recommended alternative for 30/50 beam work is 30/50 beam with 16 reinforcement diameters with a saving of IDR 451,481,095.6 or 8.4% of the project cost. The recommended alternative for conventional floor slab work is precast floor slabs with a savings of IDR 124,573,171.57 or 3% of the project cost. This step is in accordance with Mahestika (2015) regarding the recommendation stage to do cost calculations from the initial design and selected alternatives to get the size and percentage of cost savings.

4.6. Description of the Level of Difference of the Initial Superstructure Cost Budget Plan and the Value Engineering Upper Structure Cost Budget Plan

Based on the results of the independent T test, the value is sig 0.784 > 0.05. The significance level is more than 0.05, then H0 is accepted so that Ha is rejected, meaning that there is no significant average difference between the project budget plan and the value engineering budget plan. This step is in accordance with Novita's research (2020) regarding that there is an insignificant difference in carrying out a statistical t test.

5. CONCLUSION

1) Islamic University of Malang Development Project Phase 3 with parties namely Islamic Hospital of Islamic University of Malang (owner) and PT. Dwi Ponggo Seto (manufacturing contractor) is located at Jalan MT. Haryono No. 139, Dinoyo, Kec. Lowokwaru, Malang City with a budget plan for the upper structure costs Rp. 20,875,433,588.49
2) Work items that are feasible to be given alternative work to carry out value engineering analysis, namely work on main beams 40/70, joists 30/50, and floor slabs
3) The alternative proposed is main beam 40/70 diameter of 16 reinforcement, child beams 30/50 diameter of 16 reinforcement, and HCS precast plate
4) Analysis of alternative jobs to get costs, namely beam 35/70 diameter of reinforcement 19 is IDR 5,397,211,484.00, while beam 40/70 diameter of reinforcement 16 is IDR 5,234,566,133.00, beam 25/50 diameter of reinforcement 19 is IDR 4,933,369,191.00, while beam 30/50 diameter of reinforcement 16 is IDR 4,926,298,184.00, the HCS precast plate is IDR 4,647,951,520.00, while the non-palace plate is IDR 5,431,891,666.00
5) The alternative chosen and recommended to the owner is main beam 40/70 diameter of reinforcement 16 with a savings of 6.4%, joists 30/50 diameter of reinforcement 16 with a savings of 8.4%, and HCS precast plate with a savings of 3%

6) There is no significant difference between the project budget plan and the value engineering budget plan.

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