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Implementation of Value Engineering on MC House Project Kemenuh Gianyar

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Abstract

The expensive Budget Cost for MC House Construction Project in Tender Phase, causes the owner to try to safe costs in order to make it efficient. The method use Value Engineering (VE). This method could make the cost more efficient without removing the main function of the analyzed items. The goals of this research is to understand the work items which could safe the cost, alternatives recommendation for cost saving, and the total value of cost saving based on VE analysis. The process for analysis contains Information Phase, Function Analysis Phase, Creative Phase, Evaluation Phase, and Reccomendation Phase. The analysis based on Pareto Diagram results in ten work items to analyze which are Structural Work, Doors Windows and Accessories Work, Floor Finishing Work, Wall Installation Work, Wall Finishing Work, Sanitaries Work, Mechanical Work, Roof and Listplank Installation, MVAC Work, and Ceiling Work. After analysis, the total cost saving is IDR 505,822,062 or 11.27% from the first budget which is IDR 4,487,619,314. Total budget cost after analysis is IDR 3,981,797,252. Those amount is caused by several better alternatives which are Plywood Formwork + Scaffolding Work, Doors and Windows from Bengkirai Wood, Floor Finishing with Teakwood Perhutani, Wall Installation with Lightweight Concrete Thickness 10 cm, Wall Finishing with Paint Wash, Bathtub Installation with Ceramax White, Transfer Water Pump with LEO, Roof Tile Installation with Concrete Roof Tile Ex MI, AC Installation with Daikin Non Inverter, and Drop Ceiling with Bengkirai Wood.

Keywords: Value Engineering, Cost Efficiency, Alternatives

Introduction

The most common problem of construction project is discrepancy between owner construction cost limit and contractor budget cost estimate (Hatamleh et al., 2018; Shane et al., 2009). It is sometimes leads to project delay or cancellation. This problem also happen on MC House Project at Taman Petanu Ecological Neighborhood, Kemenuh, Gianyar, Bali. The amount of budget cost estimate from the contractor is IDR 4,487,619,314 while owner budget is only IDR 3,500,000,000, it is caused by the usage of expensive finishing materials. That deficiencies problem makes the project still on procurement phase from November 2023, but it means now is the right time to optimize the cost (Althabatah et al., 2023; Taboada et al., 2023).

To solve the cost insufficient problem, the owner kindly ask the contractor to make the cost more efficient by finding the method to balance the cost, quality, and looks from the choosen materials. Value Engineering can be use to solve the cost problem. According to Tohidi (2011) and Ibusuki & Kaminski (2007) Value Engineering is the products or services cost evaluation process which is still preserve the technical principals in order to reduce the cost as much as possible while maintaining the same benefits or function (Berawi, 2014). According to Value Engineering Implementation at Madrasah Ibtidaiyah Negeri 3 Gunungsitoli in order to cost savings, the replacement of material without changing the function of the said products could save about 3.76% from the first budget (Irfanto et al., 2023).

Value Engineering is the systematical and creative approach to generate cost savings and eliminate the unnecessary cost (Dahooie et al., 2020; Ongbali et al., 2024). The main objective of this research is to find the balance between cost, quality, and looks from the product by using the Value Engineering method in order to give the owner recommendation to save the cost with logical and systematical process. The first objective is to find the work items which are probably potential for Value Engineering analysis, second objective is to know what alternatives which can be use for the main work items, and third objective is to know how much the cost saving from the first budget.

Methods

The research use Value Engineering method and combined with Analytical Hierarchy Process (AHP) for decision making method. The Value Engineering method use 5 (five) process such as Information Phase, Function Analysis Phase, Creative Phase, Evaluation Phase, and Reccomendation Phase

Information Phase

In this first phase of Value Engineering procedure, all of neccessary data is collected to give a better perspective of the system, structure, or details of the object. In this phase also the work items which are potential for cost saving is being investigate in order to know which activities are the main contributor of the high budget (Preston et al., 1992). The process is use Cost Breakdown and Pareto Diagram.

Function Analysis Phase

The second phase objective is to know the basic function and secondary function of the products. This will create clear boundaries which function can be reduce or eliminate. The basic function must be kept in the analysis while secondary function could be reduce or eliminate. Value Engineering principal is to find the better alternatives while keeping the basic function.

Creative Phase

The objective of this third phase is to create alternatives which possibly can save the cost without reducing the basic function of the products. The brainstorming is conducted with the expert such as the architect and technician (Sutton & Hargadon, 1996).

Evaluation Phase

The alternatives from creative phase then being evaluated in order to know the ultimate cost from all of the alternatives (Lubart, 2001; Zhang & Zhang, 2014). The ultimate cost or Life Cycle Cost is contained construction cost, maintenance cost, and replacement cost. Then after calculating the Life Cycle Cost, analysis is continue to decision making process with Analytical Hierarchy Process. The decision is based on few criteria such as the cheaper cost, material quality, aestethic, material availability, and construction time (Ogunkah & Yang, 2012; Chen, 2020). Those criteria are also based on brainstorming with the architect or person in charge of this project.

Reccomendation Phase

The final process objectives is to presented the process and result of Value Engineering Analysis.

Results and Discussion

Information Phase

The MC House Project is located at Taman Petanu Ecological Neighborhood, Kemenuh, Gianyar, Bali. The total amount of contractor budget cost estimate is IDR 4,487,619,314 with the owner budget cost limit is IDR 3,500,000,000. The size of the land is 565 sqm with building area about approximately 396.6 sqm. The Contractor's budget cost estimate including Main Structure Work, Doors Windows and Accesories Installation, Floor Installation, Wall Installation, External Work, Preparation Work, Wall Finish Work, Sanitaries Installation, Mechanical Work, Electrical Work, Roof and Listplank, Plumbing Work, MVAC Installation, Ceiling and Partition Work, Wall Painting, and Data Installation. However, based on several reasons, these item would not be analysed such as External Work (statue and ornament installation), Preparation Work (include all of the necessaries administration cost for the project), and then electrical and plumbing work which already optimized by the MEP consultant. The budget cost estimate for pareto analysis could be describe as Table 1.

Table 1. Budget Cost Estimate for Pareto Analysis

No.	Description	Sub Total (IDR)	Percentage (%)	Comulative Percentage (%)
1	Structural Work	976,342,208.09	22%	21.8%
2	Doors, Windows, and Accessories Installation	935,054,992.18	20.8%	42.6%
3	Floor Finishing	344,377,935.26	7.7%	50.3%
4	Wall Installation	318,934,168.63	7.1%	57.4%
5	Wall Finishing	249,197,502.16	5.6%	62.9%
6	Sanitaries Installation	228,202,964.25	5.1%	68.0%
7	Mechanical Installation	190,984,960.41	4.3%	72.3%
8	Roof and Listplank Installation	151,641,672.24	3.4%	75.6%
9	MVAC Installation	105,589,912.56	2.4%	78.0%
10	Ceiling and Partition Work	100,530,105.91	2.2%	80.2%
11	Paint Finishing	25,673,552.85	0.6%	80.8%
12	Internet Data Access Installation	2,481,336.00	0.1%	80.9%

Source: Author's Analysis

Based on Table 1, then the data could be explained as Pareto Diagram on Figure 1, all of the items which on range on comulative percentage 80% are the work items which could be analyzed with Value Engineering. Those work items are Item Number 1 until Number 10 on the Table 1.

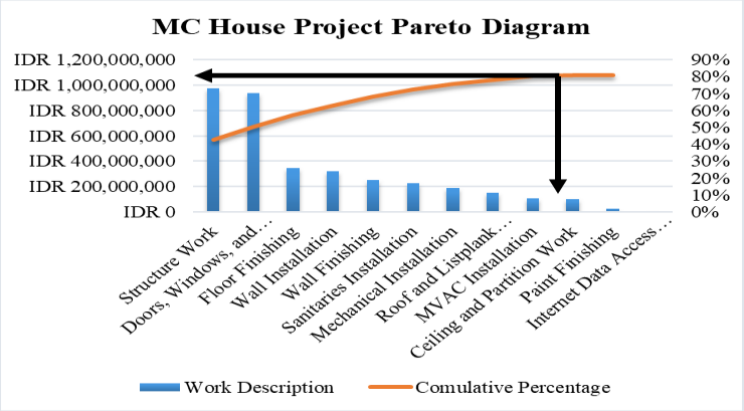

Figure 1. MC House Project Pareto Diagram
Source: Author's Analysis

Function Analysis Phase

On this phase, the work which included in the scope of Value Engineering are identified to find the basic function and secondary function. The basic function is the primary function which build the product identity and can not be eliminate from the analysis, while the secondary function is the supporting function which can be reduce or eliminate from the analysis. The summary of function analysis could be listed by Table 2.

Table 2. Function Analysis Summary

No	Main Item	Sub Item	Primary Function	Secondary Function
1	Structure Work	Formwork Installation	Accommodate Concrete	Smoothing Concrete Surface
2	Doors, Windows, and Accessories Installation	Doors and Windows Installation	Give Access	Improve Appearance
3	Floor Finishing	Teakwood Floor Installation	Take the load	Improve Appearance
4	Wall Installation	Wall Installation	Create Space	Form a Building
5	Wall Finishing	Wall Cement Expose Finishing	Cover The Wall	Create Atmosphere
6	Sanitaries Installation	Bathtub Installation	Soak The Body	Bautify The Room
7	Mechanical Installation	Booster Pump Installation	Stabilize Water Pressure	Streamline the Water Usage
8	Roof and Listplank Installation	Roof Tile Installation	Drain Rain Water	Isolate the Sound
9	MVAC Installation	AC Installation	Cooling the Room	Adjust the Room Temperature Automatically
10	Ceiling and Partition Work	Wood Drop Ceiling Accent Installation	Cover the Ceiling	Improve the Antique Value

Source: Author's Analysis

Creative Phase

In this phase, the alternatives ideas are explored and developed to archieve the primary function and combine or reduce the secondary function of the product. The alternatives ideas are obtained based on Brainstorming process with the architect or person in charge of MC House Project so it could represent a bit closer to owner preference about the materials and alternatives. The alternatives will be shown later on Reccomendation Phase. Reccomendation Phase is The Final Phase of Value Engineering Analysis Process, on this phase, the alternatives for work items are curated based on the analysis to gain the best alternatives.

Evaluation Phase

In this phase, the analysis is go through the details about Life Cycle Cost (LCC) or ultimate cost. The components are construction cost, maintenance cost, and replacement cost based on building life cycle. The maintenance and replacement cost is obtained based on Brainstorming and from the assumption of maintenance and replacement of the products which will be needed once in 5 years as long as 50 years. Then, the maintenance and replacement cost is converted

from present value into future value to estimate the future maintenance cost. For alternatives on Formwork Installation is not needing maintenance cost, ultimate cost is obtained only from construction cost. On Table 3 is outlined the result of Life Cycle Cost for Doors and Windows Installation, same method is applied to all of the analysed work items. LCC or ultimate cost result could be seen on Table 10.

Table 3. Life Cycle Cost Analysis for Doors and Windows

Description	First Plan	Alternative 1	Alternative 2
	Doors and Windows from Recycled Teakwood and Aluminium	**Doors and Windows from Teakwood Perhutani**	**Door and Windows from Bengkirai Wood**
Construction Cost (IDR)	907,155,364.28	896,818,141.57	702,453,611.15
Maintenance Cost (IDR)	389,502,257.72	444,304,383.52	371,212,495.01
Life Cycle Cost (IDR)	1,296,657,622.00	1,341,122,525.09	1,073,666,106.16
Savings Amount (IDR)		-44,464,903.09	222,991,515.84
Savings Percentage (%)		-3%	17%

Source: Author's Analysis

The next process is decision making to pick one best alternative based on a few criteria which is suit the owner preferences. The criteria is obtained from Brainstorming. Those criteria then being analyzed the priority scale using Analytical Hierarchy Process. The AHP process is start from summarize the priority scale like on the Table 4.

Table 4. Criteria Priority Scale based on Brainstorming

Criteria	Priority		Details
Cost	2	More important than	Quality
Cost	3	More important than	Appearance
Cost	4	More important than	Material Availability
Cost	5	More important than	Time
Quality	2	More important than	Appearance
Quality	3	More important than	Material Availability
Quality	4	More important than	Time

Source: Author's Analysis

According to Criteria Priority Scale on Table 4, then pairwise comparison is needed for all the criteria and it also arranged in the Pairwise Comparison Matriks Table which is shown on Table 5.

Table 5. Pairwise Comparison Matrix for Criteria

Criteria	Cost	Quality	Appearance	Material Availability	Time
Cost	1.00	2.00	3.00	4.00	5.00
Quality	0.50	1.00	2.00	3.00	4.00
Appearance	0.33	0.50	1.00	0.50	2.00

Material Availability	0.25	0.33	2.00	1.00	2.00
Time	0.20	0.25	0.50	0.50	1.00

Source: Author's Analysis

The next step is squaring the matrix for all the values from the row and collumn on Pairwise Comparison Matrix Table from Table 5 with the result as it shown on Table 6.

Table 6. The Result of Squaring the Matrix for Criteria

Kriteria	Cost	Quality	Appearance	Material Availability	Time	Total	Eigen Vector
Cost	5.000	8.083	20.500	18.000	32.000	83.58	0.4211
Quality	3.217	5.000	13.500	11.000	20.500	53.22	0.2681
Appearance	1.442	2.333	5.000	4.833	8.667	22.28	0.1122
Material Availability	1.733	2.667	6.417	5.000	10.583	26.40	0.1330
Time	0.817	1.317	3.100	2.800	5.000	13.03	0.0657
					Total	198.51	1.0000

Source: Author's Analysis

The Eigen Vector is obtained by Total Pairwise Comparison for each criteria divided by Sum of Total Pairwise Comparison for all the criteria. Then, to make sure the Eigen Vector value is consistent, the process to squaring the matrix is repeated until the Eigen Vector does not change. The end result for consistent eigen vector can be shown on Table 7. The priority order for each criteria is depends on the highest value of Eigen Vector.

Table 7. Criteria Importance Scale Recapitulation

Criteria	Eigen Vector	Ranking
Cost	0.420	Criteria No. 1 (Extreme Importance)
Quality	0.266	Criteria No. 2 (Very Strong Importance)
Appearance	0.114	Criteria No. 4 (Moderate Importance)
Material Availability	0.134	Criteria No. 3 (Strong Importance)
Time	0.066	Criteria No. 5 (Important)

Source: Author's Analysis

The alternatives for every work items are also squared on the pairwise comparison matrix based on priority scale of the criteria on the Table 7. The process for pairwise comparison is the same as the process to find the criteria priority scale, the result for alternatives pairwise comparison could be seen on Table 8.

Table 8. Eigen Vector Value Recapitulation for Doors and Windows Installation

Alternatives	Cost	Quality	Appearance	Material Availability	Time
First Plan	0.286	0.571	0.143	0.143	0.143
Alternative 1	0.143	0.286	0.571	0.286	0.286
Alternative 2	0.571	0.143	0.286	0.571	0.571

Source: Author's Analysis

After the Eigen Vector for all of the criteria and alternatives are obtained, then the value is sum up between Eigen Vector for criteria and Eigen Vector for each alternatives according to suitable criteria. For the example at the first plan : (0.286 x 0.420 + 0.571 x 0.266 + 0.143 x 0.114 + 0.143 x 0.134 + 0.143 x 0.066) = 0.317, the same process is occur for the other alternatives. The final eigen vector could be seen on Table 9.

Table 9. Ranking for Doors and Windows Installation

Alternatives	Eigen vector	Rank
First Plan	0.317	2nd
Alternative 1	0.258	3rd
Alternative 2	0.425	1st (WINNER)

Source: Author's Analysis

As it described on Table 9, the best alternative for doors and windows installation is Alternative 2 which is Doors and Windows from Bengkirai Wood as it has highest eigen vector value 0.425 among the other alternatives. This process is also applied for all of the work which are on the scope of Value Engineering Analysis.

Reccomendation Phase

Based on the analysis at previous process, then on Table 10 is described a few alternatives along with the ultimate cost and eigen vector value for all of the analyzed work items. Alternatives which is bold are the winner and reccomended on this research.

Table 10. Decision Making Result with AHP

No	Description		First Plan	Alternative 1	Alternative 2
1	Formwork Installation	Spesification (Cost)	Plywood Formwork and Bamboo Scaffolding (IDR 47,604,872)	Plywood Formwork and Iron Scaffolding (IDR 47,130,938)	Metal Deck Formwork and Bamboo Scaffolding (IDR 99,097,720)
		Eigen Vector	0.251 (Ranking 3)	0.423 (Ranking 1)	0.326 (Ranking 2)
2	Doors and Windows	Spesification (Cost)	Doors and Windows by Recycled Teakwood and Aluminium (IDR 1,296,657,622)	Doors and Windows by Teakwood Perhutani (IDR 1,341,122,525)	Doors and Windows by Bengkirai Wood (IDR 1,073,666,106)
		Eigen Vector	0.317 (Ranking 2)	0.258 (Ranking 3)	0.425 (Ranking 1)
3	Floor Finishing	Spesification (Cost)	Javanese Recycled Teakwood Floor (IDR 231,334,989)	Perhutani Teakwood Floor (IDR 147,134,023)	Bengkirai Wood Floor (IDR 138,692,742)
		Eigen Vector	0.230 (Ranking 3)	0.419 (Ranking 1)	0.351 (Ranking 2)
4	Wall Installation	Spesification (Cost)	Lightweight Brick 12.5 cm Thick (IDR 98,205,747)	Lightweight Brick 10 cm Thick (IDR 79,147,139)	Sandwich Panel Wall Ex Citicon (IDR 288,803,011)
		Eigen Vector	0.336 (Ranking 2)	0.444 (Ranking 1)	0.222 (Ranking 3)
5	Wall Finishing	Spesification (Cost)	Wall Finish Cement Expose Instant Mix (IDR 156,391,061)	Wall Finish Cement Expose Manual Mix (IDR 214,167,475)	Paint Wash Finish (IDR 74,078,144)

		Eigen Vector	0.343 (Ranking 2)	0.287 (Ranking 3)	0.370 (Ranking 1)
6	Sanitaries Installation	Spesification (Cost)	Bathtub Installation Ex Toto Alisei (IDR 114,577,191)	Bathtub Installation Ex Ceramax (IDR 13,723,154)	Bathtub Installation Ex Cleo (IDR 23,369,358)
		Eigen Vector	0.321 (Ranking 2)	0.390 (Ranking 1)	0.290 (Ranking 3)
7	Mechanical Installation	Spesification (Cost)	Booster Pump Installation Ex. Grundfos (IDR 54,723,017)	Booster Pump Installation Ex. Leo (IDR 44,790,516)	Booster Pump Installation Ex. Drakos and Transfer Pump Ex. Leo (IDR 14,751,204)
		Eigen Vector	0.286 (Ranking 3)	0.282 (Ranking 2)	0.432 (Ranking 1)
8	Roof and Listplank Installation	Spesification (Cost)	Concrete Roof Tile Ex Cisangkan (IDR 88,208,451)	Concrete Roof Tile Ex MI (IDR 59,464,479)	Concrete Roof Tile Ex Indoprecast (IDR 80,400,291)
		Eigen Vector	0.376 (Ranking 2)	0.409 (Ranking 1)	0.215 (Ranking 3)
9	MVAC Installation	Spesification (Cost)	AC Daikin Inverter Installation (1/2 , 3/4, dan 2.5 PK) (IDR 85,520,232)	AC Daikin Non Inverter Installation (1/2 , 3/4, dan 2.5 PK) (IDR 69,338,517)	AC Gree Non Inverter Installation (1/2 , 3/4, dan 2.5 PK) (IDR 71,949,685)
		Eigen Vector	0.273 (Ranking 3)	0.389 (Ranking 1)	0.337 (Ranking 2)
10	Ceiling and Partition Work	Spesification (Cost)	Recycled Teakwood Drop Ceiling Accent Installation (IDR 42,591,054)	Perhutani Teakwood Drop Ceiling Accent Installation (IDR 44,688,596)	Bengkirai Wood Drop Ceiling Accent Installation (IDR 32,107,582)
		Eigen Vector	0.366 (Ranking 2)	0.226 (Ranking 3)	0.408 (Ranking 1)

Source: Author's Analysis

Conclusion

Based on Pareto Analysis, there are ten work items which could be analyzed using Value Engineering, those work items such as Structure Work, Doors Windows and Accessories, Floor Finishing, Wall Installation, Wall Finishing, Sanitaries Installation, Mechanical Work, Roof and Listplank Installation, MVAC Installation, and Ceiling and Partition Installation. The alternatives which are recommended for the project to save the cost Structure Work (Formwork Installation), could be replaced with Plywood Formwork with Iron Scaffolding. Doors, Windows, and Accessories Installation, could be replaced with Doors and Windows from Bengkirai Wood. It could safe the cost significantly about 17% from first plan. Flooring Installation, could be replaced with Perhutani Teakwood Floor which have a competitive cost. Wall Installation, could be replaced with Lightweight Brick 10 cm Thick. Sanitaries Installation, could be replace with Bathtub Ex Ceramax White, so the owner could safe the cost about 88% lower than the first plan. Mechanical Work, could be replace with combination of Booster Pump Ex Drakos DCHM 4-50 and Transfer Pump LEO AJM 75 P. With that combination owner could safe the cost about 73% cheaper than first plan. Roof and Listplank Installation, could be replace with Concrete Roof Tile Ex MI, it could safe the cost significantly about 33% from the first plan. MVAC (Motor Vehicle Air Conditioner), could be replaced with AC Daikin Non Inverter and significantly reduce the cost about 19% from the first plan. For

Ceiling and Partition Work, could be replaced with Drop Ceiling from Bengkirai Wood. The cost calculation from every alternatives could save the cost about IDR 547,776,301 or 12.21% from the first estimate budget which is IDR 4,487,619,314 so the final cost for the budget is IDR 3,939,843,013.

Suggestion

Based on the Value Engineering analysis and discussion with the architect, a few factors that make the budget high is arched doors and windows design, recycled teakwood for flooring, and complexity of wall finishing, the author hopes this research could be use by the owner to help consider the design of overall building to save the cost. For the next research, the Analytical Hierarchy Process can use more criteria other than cost, quality, appearance, material availability, and construction time in order to make the decision more accurate.

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