Value Engineering Analysis of Architectural Works in Construction Projects

(Case Study of Citra Arafiq Serang Hospital Development)

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ABSTRACT

The development of construction projects cannot be separated from project control management, one of which is construction cost management. In its implementation, there are many problems that cause cost overruns. The objectives of this research are to identify architectural work components that have the potential to be value engineered, to determine the difference in project costs before and after value engineering is applied, and to determine the project cost efficiency obtained after the application of value engineering. The research method used in this research is Value Engineering Work Plan which consists of information stage, function analysis stage, creative stage, evaluation stage, development stage, and recommendation stage. Life Cycle Cost (LCC) analysis and Analytical Hierarchy Process (AHP) method were used to determine the value of work efficiency. From the results of the research, it was found that walls, partitions, ceilings, and floors are architectural work items that can be applied to VE Analysis. The cost difference from the results of replacing the initial design with the recommended design, obtained a total cost savings of Rp 2.454.714.553,78 from the total cost of architectural work of Rp 11.178.625.221,13.

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1. INTRODUCTION

Project development is a planned activity using various resources and funds to achieve a goal. This activity always aims to achieve a goal and has a starting point and an end point that can be measured [1]. Construction projects cannot be separated from project control management, one of which is cost control. During the development process, cost control is very important. Many problems can arise during the project. These include wasteful use of materials, choice of materials, limited resources and labor, lack of infrastructure support, and late project completion, which can cause costs to increase or be wasted [2].

There is one method that can be used to avoid these cost problems. Value Engineering is a planned and creative approach to determining the cost of construction projects. It is used to find alternatives or ideas to lower or increase the cost according to the pre-planned price considering functional constraints and quality of work [3].

Based on data and studies that have been conducted previously, Value Engineering can find the optimal cost and cost efficiency of a construction project.The average amount of cost optimization achieved in the range of 3 - 15% of the total cost.Thus Value Engineering can be one of the solutions to find optimization of construction projects as well as to reduce construction costs so that they become more efficient.

2. METHOD

The research method used in this research is adjusted to the Value Engineering Work Plan which consists of the information stage, function analysis stage, creative stage, evaluation stage, development stage, and recommendation stage.Life Cycle Cost (LCC) analysis and Analytical Hierarchy Process (AHP) method were used to determine the value of work efficiency.To assess the validity of the research, expert validation was carried out to determine the weight on the optimization criteria and to assess the validity of the research process and results. All stages were illustrated with a research flow chart.

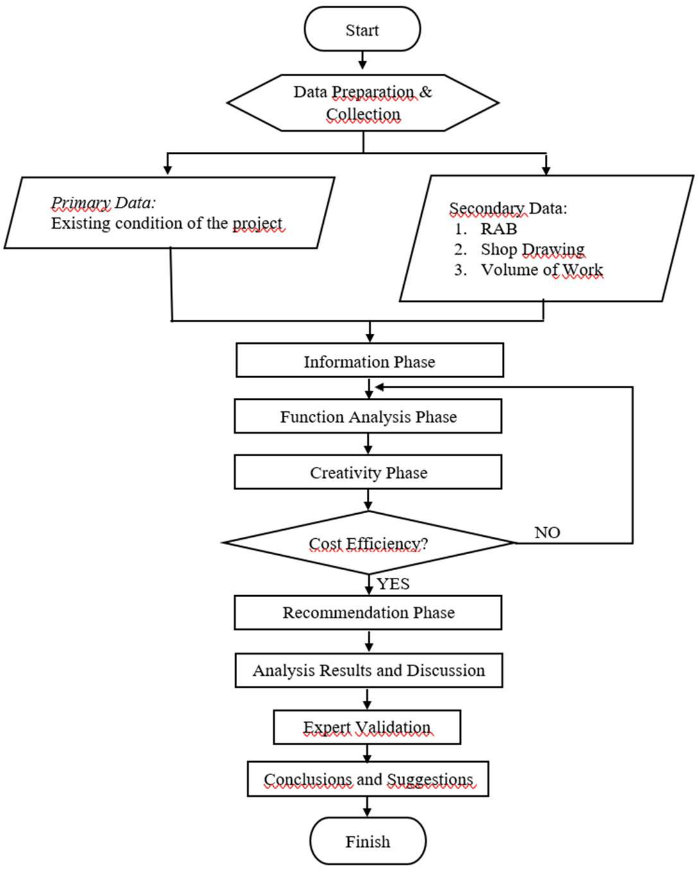

Figure 1. Research Flow Chart

2.1 Data

The data in this study is in the form of secondary data consisting of a Cost Budget Plan (RAB), project working drawings, and work volumes. As well as primary data in the form of direct observations and conditions in the review project.

2.2 *Value Engineering*

Value Engineering is the application of value methodology to projects designed to increase value. Value methodology is a systematic process used by a multidisciplinary team to increase the value of a project by analyzing its functions [4]. The Value Engineering (VE) method focuses on value to achieve an optimal balance between time, cost, and quality by using systematic value management and innovation. This method is designed to provide a competitive advantage for a product [4]. The concept of value engineering emphasizes the cost of the product or service. At the lowest possible cost, this technique strives to achieve minimal standards. [5]

The VE concept considers the relationship between function and cost to increase the value of a product. Alternative value relationships with functions and costs are as follows [22] :

Value $= \frac{\rightarrow}{\downarrow}$: Maintaining function and reducing costs..

Value $= \frac{\uparrow}{\rightarrow}$: Improve function while maintaining cost.

Value $= \frac{\uparrow}{\downarrow}$: Improve function and reduce cost.

Value $= \frac{\uparrow}{\uparrow}$: Improve function while increasing cost.

The stages of VE start from the information gathering stage, function analysis stage, creativity stage, evaluation stage, development stage, and presentation stage, all of which are carried out systematically.

2.2.1 Information Phase

The information stage is intended to obtain as much information as possible during the project design stage [6]. The purpose of this step is to understand the state of the project and the obstacles that may affect project decisions. The results will give all VE team members a broad understanding of the project [4].

2.2.2 Function Analysis Stage

Function analysis is the process of defining classifying, and evaluating functions in VE study activities. This stage aims to understand the project work based on its function value. Determination of function value is done by giving Cost and Worth values for the main function according to the unit price of the work. Then for supporting functions, filling is only done in the Worth column which makes a difference in value. We then divide the difference to calculate the function value with the following conditions.

The functional approach includes an understanding of the description, research, and analysis of the project to be conducted that will strategically address the functional aspects of the project [6].

$$\frac{Cost}{Worth} > 1 \text{ indicates the potential for savings} \quad (1)$$

2.2.3 Creativity Phase

The creative stage is the stage of developing an alternative idea to achieve a function based on the information that has been obtained without reducing the function of the product or work.

2.2.4 Evaluation Phase

This stage is aimed at identifying alternative ideas and looking for the most potential ideas in increasing value [4]. This stage provides answers about which creative ideas can be developed to increase the value of a project.

2.2.5 Development Phase

This stage is an advanced analysis phase and develops a short list of ideas and develops these by taking into account value alternatives [3]. The purpose of this stage is to develop the selected ideas into clear written value alternatives so that the parties involved in the project can understand the purpose of the alternatives and how they can benefit the project [7].

2.2.6 Recommendation Phase

This is the last phase of the value engineering work plan. At this stage, the best alternative design is selected by providing the basics of its consideration. At this phase, a very careful and detailed review of all proposed alternative solutions is carried out to ensure that the high value [17]. The result of these activities is to help project stakeholders decide what to change in product design or development [23].

2.3 Analisis *Life Cycle Cost*

The life cycle costing method is used to select the best method from a range of options to achieve the lowest long-term cost. The results of this calculation will be used as a criterion in selecting the existing options [8]. Life Cycle Cost takes into account costs from construction, operation, maintenance, replacement, and salvage value.

The life cycle costing method is used to select the best method from a range of options to achieve the lowest long-term cost. The results of this calculation will be used as a criterion in selecting the options [8].

The life cycle cost of a construction project consists of costs from the beginning of construction until the building fulfills its function, including initial costs, operational costs, maintenance costs, and demolition costs [21].

$$LCC = Construction + Operation + Maintenance + Replacement\ Cost \quad (2)$$

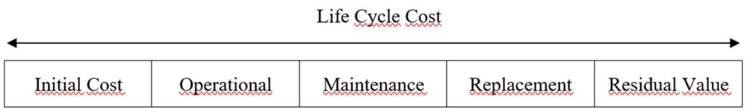

Figure 2. Life Cycle Cost

2.4 *Analytical Hierarchy Process*

AHP is one of the tools (processes) in decision making. This method is used to determine the priority scale of each component. AHP is one of the most effective methods because each priority consists of all criteria that allow the achievement of a goal in decision making [9].

AHP is carried out pairwise comparisons of all existing elements to produce a scale of relative importance of these elements. The resulting rating scale is a numerical scale, and if these comparisons are combined, it will produce priorities [11].

The weighting value that has been given by the expert is normalized to find out and calculate the percentage value of each criterion. For the calculation of weighting normalization (eigen value) can be seen as follows :

$$\text{Criteria} = \frac{\text{value in column}}{\text{sum in column}} \quad (3)$$

AHP comparison value, calculated by multiplying the average value of the criteria against the average value of each alternative.

$$\text{AHP Value} = \text{Average criteria} \times \text{average alternatives against criteria} \quad (4)$$

3. RESULT AND DISCUSSION

3.1 Information Phase

The information stage is carried out by collecting data in the form of the cost of each work item with details in tables 3 and 4.

Table 3. ***Breakdown Cost Model***

Work Items	Cost (Rp)	Cost (%)
Preparatory Work	639.769.282,79	2,58
Foundation Work	4.959.712.410,21	20,00
Structure Work	4.779.580.274,49	19,27
Architectural Work	11.178.625.221,13	45,07
Mechanical-Electrical Work	1.422.770.405,00	5,74
Water Sanitation and Plumbing Works	1.583.721.844,50	6,38
External Works	240.566.851,00	0,97
Amount	24.804.746.289,12	100

In Table 3, it can be seen that architectural works have the highest percentage compared to other works.

Table 4. Breakdown Cost Model Architectural Work

Item Pekerjaan	Biaya (Rp)	Biaya (%)
Wall Work	2.875.508.556,50	25,72
Partition work	1.750.102.200,00	15,66
Ceiling work	1.599.068.106,90	14,30
Floor Work	4.325.819.080,80	38,70
Door & Window Work	501.222.958,13	4,48
Ceramic Wall Work	126.904.318,80	1,14
Jumlah	11.178.625.221,13	100

Based on Table 4, VE analysis will be conducted on wall, partition, ceiling, and floor works. This is because these works have the highest cost compared to other works.

3.2 Function Analysis Phase

The function analysis stage is carried out by comparing the value of worth (main function) with cost (supporting function). With a recapitulation of the function analysis results in table 5.

Table 5. Architectural Job Function Analysis

Work Items	Worth (Rp)	Cost (Rp)	Worth/Cost
Wall Work	310.668,79	231.759,23	1,34
Partition work	299.960,25	267.901,70	1,12
Ceiling work	203.773,10	145.771,70	1,40
Floor Work	2.142.178,40	1.507.390,10	1,42

3.3 Creativity Phase

In the creative stage, a search for various alternative jobs is carried out which will later be carried out in the life cycle cost calculation process, this is done to find other alternative jobs that have the potential for greater optimization value. At this stage, a list of alternative ideas was generated to achieve the function that had the potential to create increased value [18]

1. Wall Work Alternatives
   Alternatives for wall works can be seen in Table 6.

Table 6. Alternative Wall Work

Notation	Alternative
A0	Fit. Hebel Bricks (Uk. 60x20x10), Adhesive, Plaster, Acian, Sealer, Paint
A1	Fit. Red Brick (Uk. 10), mortar, plaster, aci, sealer, paint
A2	Fitting. Brick/Conblock (Uk. 40x20x10), mortar, plaster, aci, sealer, paint
A3	Fitting. Lightweight Brick Panel (Uk. 10), plaster, paint

2. Partition Work Alternatives
   Alternatives for partition works can be seen in Table 7.

Table 7. Partition Work Alternatives

Notation	Alternative
B0	Gypsum (Uk. 240x120x9), C75 Canal Frame, paint
B1	Double Plywood, Grade II timber frame
B2	GRC board, C-75 canal frame, paint
B3	Triplex board, Class II timber frame

3. Ceiling Work Alternatives
   Alternatives for ceiling works can be seen in Table 8.

Table 8. Ceiling Work Alternatives

Notation	Alternative
C0	Gypsum (Uk. 240x120x9), hollow frame (Uk. 2x4 & 4x4), screws, compound, sealer, ceiling paint
C1	Triplex (Uk. 120 x 240), hollow frame, ceiling paint
C2	Asbestos cement, wooden frame, ceiling paint
C3	GRC board, wooden frame, ceiling paint

4. Floor Work Alternatives
   Alternatives for floor works can be seen in Table 9.

Table 9. Floor Work Alternatives

Notation	Alternative
D0	Lantai Ubin Granit (Uk. 60x60), screed 3,5, plint granit 10x40
D1	Lantai Marmer Lokal (Uk. 60x60), screed 2 cm, plint marmer 10x60
D2	Lantai Keramik Ubin (Uk. 60x60), screed 2 cm, plint keramik 10x20
D3	Lantai Ubin Homogen (60x60), screed 2 cm, plint homogen

3.4 Life Cycle Cost Analysis

Based on the analysis of life cycle costs that have been calculated starting from construction costs, operational costs, maintenance costs, replacement costs, and residual value of architectural work, the results are shown in the following tables.

1. Life Cycle Cost of Wall Work
   A recapitulation of the calculation of the life cycle cost of wall work can be seen in table 10.

Table 10. Recapitulation of Life Cycle Cost of Wall Work

Cost Type	Initial Design (Rp)	Alternative 1 (Rp)	Alternative 2 (Rp)	Alternative 3 (Rp)
Construction Cost	2.875.508.556,50	1.995.512.352,72	2.773.886.514,96	2.875.681.745,76
Operating Costs	-	-	-	-
Maintenance Costs	-	-	-	-
Replacement Cost	1.106.968.249,59	1.106.968.249,59	1.106.968.249,59	1.106.968.249,59
Residual Value	2.346.554.707,56	1.146.116.465,64	2.313.677.709.00	2.466.370.555,20

2. Life Cycle Cost of Partition Work
A recapitulation of the calculation of the life cycle cost of partition work can be seen in table 11.

Table 11. Recapitulation of Life Cycle Cost of Paritition Work

Cost Type	Initial Design (Rp)	Alternative 1 (Rp)	Alternative 2 (Rp)	Alternative 3 (Rp)
Construction Cost	1.750.102.200,00	1.072.305.080,00	1.762.995.080,00	1.030.702.680,00
Operating Costs	-	-	-	-
Maintenance Costs	-	-	-	-
Replacement Cost	1.169.737.726,24	1.176.500.232,48	1.170.205.023,55	1.174.992.370,05
Residual Value	122.047.660	195.888.700,00	128.494.100,00	194.536.300,00

3. Life Cycle Cost of Ceiling Work
A recapitulation of the calculation of the life cycle cost of ceiling work can be seen in table 12.

Table 12. Recapitulation of ceiling work life cycle cost

Cost Type	Initial Design (Rp)	Alternative 1 (Rp)	Alternative 2 (Rp)	Alternative 3 (Rp)
Construction Cost	1.599.068.106,90	1.579.212.669,90	1.474.289.500,50	1.560.608.500,50
Operating Costs	-	-	-	-
Maintenance Costs	-	-	-	-
Replacement Cost	916.061.317,17	915.080.703,51	912.979.966,38	916.108.564,18
Residual Value	156.810.420	146.990.700	118.010.700	161.170.200

4. Life Cycle Cost of Floor Work
A recapitulation of the calculation of the life cycle cost of floor work can be seen in table 13.

Table 13. Recapitulation of Life Cycle Cost of Floor Work

Cost Type	Initial Design (Rp)	Alternative 1 (Rp)	Alternative 2 (Rp)	Alternative 3 (Rp)
Construction Cost	4.208.471.470,80	3.080.119.330,80	2.753.100.730,80	3.757.629.960,00
Operating Costs	-	-	-	-
Maintenance Costs	-	-	-	-
Replacement Cost	134.762.920,10	95.070.842,51	83.218.183,52	119.626.945,59
Residual Value	2.297.084.175.00	1.592.611.425,00	889.937.712,00	1.859.737.805,71

3.5 *Analytical Hierarchy Process* (AHP)

The AHP method is carried out by conducting parallel comparisons between criteria and job alternatives. That way it allows weighting to find the best criteria and alternatives. Conducted to experts to determine which work alternatives have an optimization value to make cost savings. The Analytic Hierarchy Process (AHP) helps tackle complex problems by constructing a hierarchy of criteria, subjectively assessing stakeholders, and drawing on multiple considerations to determine weights or priorities [19]

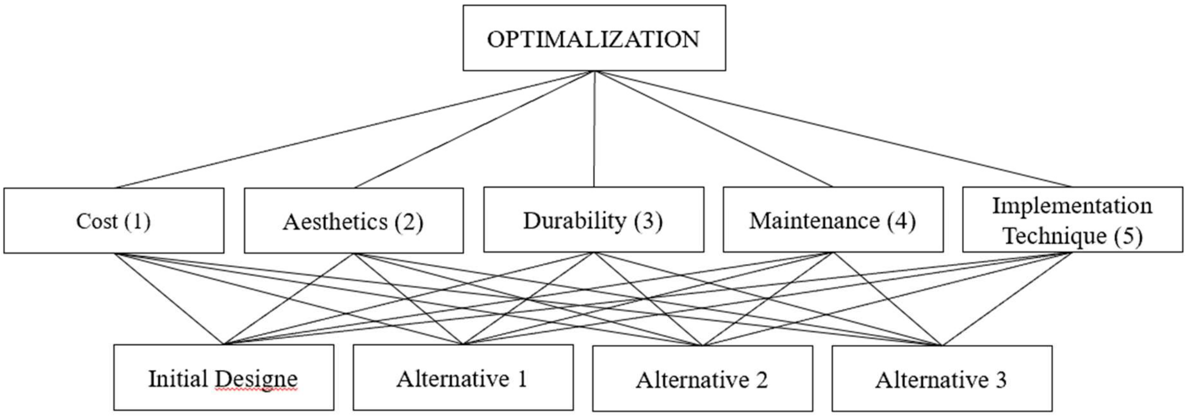

Figure 3. AHP Hierarchical Structure

The parallel comparison is carried out in two stages, first comparing each optimization criterion then afterwards a parallel comparison between job alternatives is carried out.

Table 14. AHP Calculation Results on Optimization Criteria

Criteria	Criteria					Amount	Average	%
	1	2	3	4	5			
1	0.3003	0.2341	0.2886	0.3618	0.2753	1.4600	0.2920	29.20
2	0.1892	0.1475	0.1527	0.1333	0.1394	0.7621	0.1524	15.24
3	0.2292	0.2127	0.2202	0.2116	0.2086	1.0823	0.2165	21.65
4	0.1218	0.1623	0.1527	0.1467	0.1884	0.7718	0.1544	15.44
5	0.1596	0.2435	0.1858	0.1467	0.1884	0.9238	0.1848	18.48
JUMLAH						**5**	**1**	**100,00**

Table 14 shows that the cost criterion is the most important criterion than the other criteria because it has a percentage value for optimization of 29.20%.

AHP calculations on wall work can be seen in table 15.

Table 15. AHP Calculation Results of Wall Work

Criteria	Criteria Weight (%)	Alternative			
		A0	A1	A2	A3
1	29.20	0.1082	0.1142	0.0450	0.0245
2	15.24	0.0269	0.0684	0.0275	0.0295
3	21.65	0.0399	0.0995	0.0345	0.0425
4	15.44	0.0453	0.0360	0.0372	0.0358
5	18.48	0.0764	0.0372	0.0451	0.0260
Amount	1	0,30	0,36	0,19	0,16
Percentage	100	29,68	35,54	18,93	15,85

AHP calculations on partition work can be seen in table 16.

Table 16. AHP Calculation Results of Partition Work

Criteria	Criteria Weight (%)	Alternative			
		B0	B1	B2	B3
1	29.20	0.1163	0.0489	0.0524	0.0744
2	15.24	0.0497	0.0336	0.0439	0.0253
3	21.65	0.0574	0.0521	0.0808	0.0262
4	15.44	0.0447	0.0307	0.0482	0.0307
5	18.48	0.0823	0.0356	0.0479	0.0190

Amount	1	0,35	0,20	0,27	0,18
Percentage	100	35,03	20,09	27,32	17,56

AHP calculations on ceiling work can be seen in table 17.

Table 17. AHP Calculation Results of Ceiling Work

Criteria	Criteria Weight (%)	Alternative			
		C0	C1	C2	C3
1	29.20	0.0466	0.1078	0.0575	0.0802
2	15.24	0.0855	0.0286	0.0210	0.0173
3	21.65	0.1133	0.0628	0.0173	0.0230
4	15.44	0.0584	0.0285	0.0316	0.0358
5	18.48	0.0679	0.0364	0.0459	0.0345
Amount	1	0,37	0,26	0,17	0,19
Percentage	100	37,17	26,41	17,34	19,08

AHP calculations on floor work can be seen in table 18.

Table 18. AHP Calculation Results Floor Work

Criteria	Criteria Weight (%)	Alternative			
		D0	D1	D2	D3
1	29.20	0.0381	0.0680	0.1037	0.0822
2	15.24	0.0689	0.0330	0.0247	0.0258
3	21.65	0.0925	0.0451	0.0459	0.0330
4	15.44	0.0321	0.0316	0.0582	0.0325
5	18.48	0.0528	0.0427	0.0584	0.0309
Amount	1	0,28	0,22	0,29	0,20
Percentage	100	28,44	22,04	29,08	20,44

3.6 Recommendations Phase

For the results of cost calculations of all alternatives can be seen in table 19.

Table 19. Work Cost Recapitulation

Item Works	Initial Design (Rp)	Alternative 1 (Rp)	Alternative 2 (Rp)	Alternative 3 (Rp)
Wall	2.875.508.556,50	1.995.512.352,72	2.733.886.514,96	2.875.681.745,76
Partitions	1.750.102.200,00	1.072.305.080,00	1.762.995.080,00	1.030.702.680,00
Ceiling	1.599.068.106,90	1.579.212.669,90	1.474.289.500,50	1.560.608.500,50
Floor	4.325.819.080,80	3.080.119.330,80	2.753.100.730,80	3.757.629.960,00

From the stages passed, for a comparison of the price of work items and each alternative, see Figure 4.

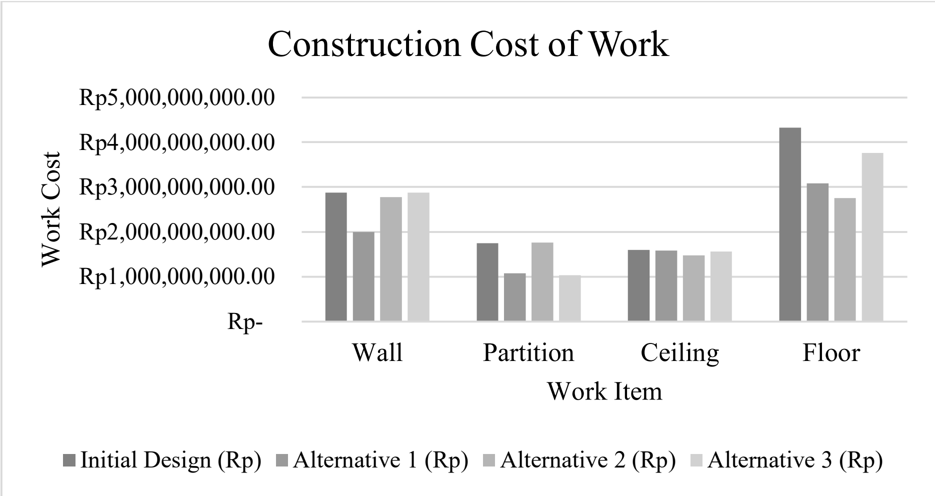

Figure 4: Comparison Chart of Job Construction Costs

Next is the recapitulation of the optimization value on the work items and their alternatives.

Table 20. Recapitulation of Job Optimization Value

Work Item	Initial Design (%)	Alternative 1 (%)	Alternative 2 (%)	Alternative 3 (%)
Wall	29.68	35.54	18.93	15.85
Partitions	35.03	20.09	27.32	17.56
Ceiling	37.17	26.41	17.34	19.08
Floor	28.44	22.04	29.08	20.44

In table 5.20, it can be concluded that the selected alternative work is:
Wall Work: Alternative 1 (A1)
Partition Work: Initial Design (B0)
Ceiling Work: Preliminary Design (C0)
Floor Work: Alternative 2 (D2)

Thus the recommendation cost and the amount of savings generated after the VE stages are obtained.

Table 21. Recapitulation of Cost Savings

Work Item	Construction Cost		LCC Cost	
	Initial Design (Rp)	Recommendation (Rp)	Initial Design (Rp)	Recommendation (Rp)
Wall	2.875.508.556,50	1.955.512.352,72	6.262.280.939,84	4.248.597.067,95
Partitions	1.750.102.200,00	1.750.102.200,00	3.041.887.586,24	3.041.887.586,24
Ceiling	1.599.068.106,90	1.599.068.106,90	2.515.286.234,49	2.515.286.234,49
Floor	4.325.819.080,80	2.753.100.730,80	6.640.318.565,90	3.726.256.515,00
Amount	**10..550.497.944,20**	**8.097.783.390,42**	**18.459.773.326,47**	**13.532.027.515,00**
Saving	**2.452.714.553,78**		**4.927.745.811,47**	

For a brief comparison of the construction cost savings obtained can be seen in Figure 5.

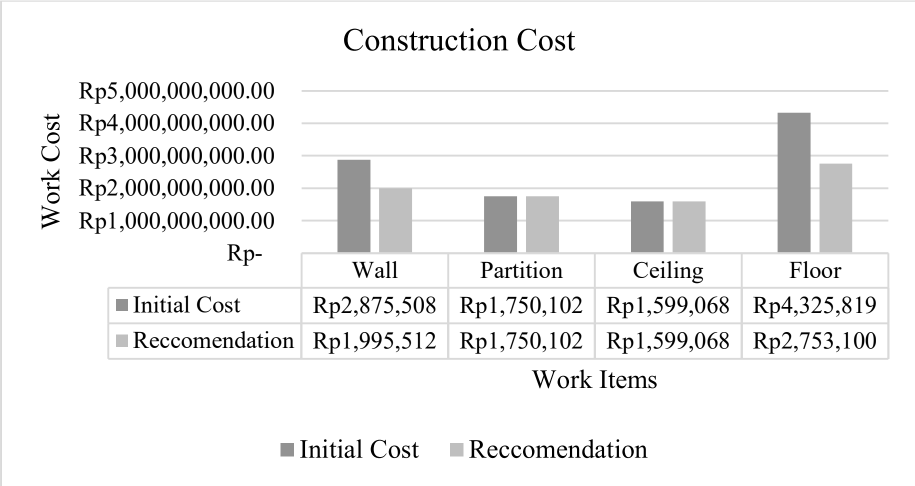

Figure 5. Construction Cost Chart of Initial Design and Recommendation

For a brief comparison of the LCC cost savings obtained can be seen in Figure 6.

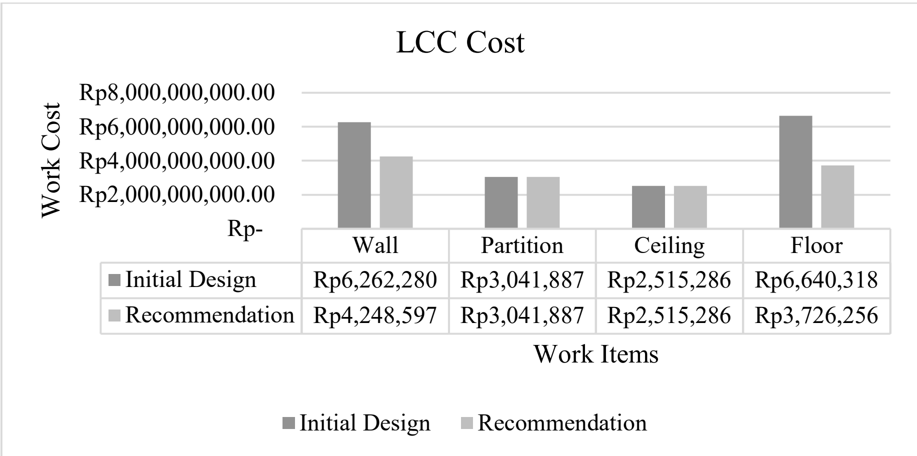

Figure 6. LCC Cost Chart of Initial Design and Recommendation

Of the two alternatives, the total cost of the recommendation is Rp. 2,454,714,553.78. Then the percentage of cost savings obtained on the cost of architectural work is as follows

$$\% \text{ saving} = \frac{\text{recommendation cost}}{\text{architectural cost}} \times 100\% = \frac{2.452.714.553{,}78}{11.178.625.221{,}13} \times 100\% = 21{,}94\ \%$$

$$\% \text{ saving} = \frac{\text{recommendation cost}}{\text{amount cost}} \times 100\% = \frac{2.452.714.553{,}78}{24.804.746.289{,}12} \times 100\% = 9{,}89\ \%$$

4. CONCLUSION

The work that is reviewed for the application of Value Engineering is architectural work, this is because architectural work has the largest percentage weight with a value of 45.07% compared to other work. With a large work weight, the potential for cost overruns and cost savings is great. Therefore, value engineering analysis is carried out on architectural work sub-items including wall work, partition work, ceiling work, and floor work.

After conducting a value engineering analysis, it was found that the difference in cost from the results of replacing the initial design with the recommended design, obtained a total cost savings of Rp. 2,454,714,553.78 from the total cost of architectural work of Rp. 11,178,625,221.13. The use of the AHP method to the three experts resulted in cost savings of 21.94% of the architectural work cost and 9.89% of the total project cost. While the life cycle cost savings (LCC) is Rp. 4,927,745,515.00.

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