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ABSTRACT

Cost efficiency is an important aspect of project planning. One common approach to increasing cost efficiency is value engineering. This study applies Value Engineering to the Padang Sambian 1 Public Elementary School Building Construction Project with a total planned budget of IDR. 10,019,488,000.00. The analysis was conducted using the Dell'Isola method, which consists of four stages: information, creative, analytical, and recommendation. Based on the results of the study, the items carried out by Value Engineering include concrete work items on floors 1, 2, 3 and the roof, wooden plank truss work and roof tiles (roof work), door window hanging and locking work on floors 1, 2, and 3, masonry and plastering work (wall work) on floors 1, 2, and 3, paving block installation, ceramic floor and wall installation on floors 1, 2, and 3, and ceiling work on floor 3. The cost efficiency obtained using the Dell'Isola theory value engineering method is IDR. 224,566,091.39 or 2.24% of the total project cost with details of savings of IDR. 69,226,207.23 on concrete work on floors 1, 2, 3, and roof, IDR. 58,015,626.87 on truss work, wooden planks and roof tiles (roof work), IDR. 6,890,888.88 on door and window hanging and locking work on floors 1, 2, and 3, IDR. 1,160,097.63 on masonry and plastering work (wall work) on floors 1, 2, and 3, IDR. 48,561,507.2 on paving block masonry, IDR. 18,528,260.2 on ceramic floor and wall masonry on floors 1, 2, and 3, and IDR. 22,183,503.3 on the 3rd floor ceiling work. The benefits of applying value engineering are that it can reduce project costs without reducing the function, quality, and performance of the building, while providing a more efficient technical basis for decision-making at the planning and construction implementation stages.

Keywords: cost efficiency; Dell'Isola; value engineering

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1. INTRODUCTION

A construction project is a series of organized activities carried out within specific quality, cost, and time constraints, requiring construction management capable of coordinating all resources effectively and efficiently (Wang et al., 2021). However, in practice, various problems frequently occur, such as material waste, low labor productivity, and work delays, which result in increased project costs. This situation indicates that suboptimal planning and cost control remain major issues in construction project implementation, including the construction of educational facilities.

In Indonesia, budget overspending on school construction projects is common (Purba, 2024). This waste is generally caused by inefficient designs and material specifications, excessive use of structural dimensions, and a lack of evaluation of more economical alternative materials and work methods. Consequently, project budgets increase without significantly improving the function or quality of the building. This is a significant concern, as school construction should prioritize the effective use of funds to support optimal teaching and learning activities.

Furthermore, limited education funding from the Regional Budget (APBD) demands efficiency in all educational facilities and infrastructure development. These budget constraints require local governments to carefully manage funds to meet a wider range of educational needs. Cost inefficiencies in one project can delay the construction or rehabilitation of other educational facilities, making cost control and optimization crucial.

In the Padang Sambian 1 Public Elementary School Building Construction Project, construction costs are quite large, so careful budget calculations are essential to avoid waste. A preliminary study using a Pareto diagram revealed that the largest cost overruns occurred in architectural and structural work (Meilasari et al., 2023). In architectural work, the use of materials, such as concrete blocks, camphor wood for door frames, and toilet wall tiles, contributed to high costs, despite the availability of more economical alternative materials that still meet the building's function and aesthetics. Meanwhile, in structural work, a relatively large number of columns and larger column dimensions were found than required, significantly increasing the volume of concrete, reinforcement, and formwork.

These issues highlight the need for more appropriate design evaluation and material selection to reduce costs without compromising the building's strength, safety, and durability. One method that can be applied is value engineering, a systematic and creative approach to analyzing designs, specifications, and work methods to identify more economical alternatives without compromising the function and quality of a building (Elhegazy, 2022). Various studies have shown that the application of value engineering can generate significant cost savings without sacrificing the structural quality or aesthetics of a building.

The application of value engineering to the Padang Sambian 1 Public Elementary School building project is a strategic step to improve construction cost efficiency through design evaluation and work specifications. Furthermore, this approach is not only relevant to this project but is also important as a reference in educational facility development policies in general. By implementing value engineering, costs that do not provide added value to the building's function can be minimized, allowing the available budget to be allocated more effectively to support comfort, safety, and the continuity of the learning process. Therefore, value engineering is a crucial strategy for realizing efficient, high-quality, and sustainable school building construction.

Various previous studies have shown that the application of Value Engineering (VE) can produce significant cost efficiencies in construction projects without compromising the building's functionality. However, most of these studies have focused on commercial, high-rise, or large-scale infrastructure buildings. Research specifically examining the application of Value Engineering in elementary education buildings is still relatively limited, especially in Indonesia. Furthermore, studies that integrate Value Engineering analysis with technical evaluation of structures using structural analysis software to assess the safety and performance of alternative designs have not been widely conducted. Therefore, this study was conducted to fill this research gap by applying Value Engineering methods to the construction project of Padang Sambian 1 Public Elementary School, with the aim of obtaining a more cost-efficient structural design alternative without compromising the function and safety of the building structure.

2. LITERATURE REVIEW

2.1. Overview of value engineering

Value engineering is a systematic and organized approach that aims to increase the value of a product or project through functional analysis to obtain the most efficient solution without compromising quality or performance (Husal et al., 2024). This method is carried out by reviewing the design, identifying unnecessary costs, and formulating alternatives that can provide equivalent functions at a lower cost. This concept emphasizes the relationship between costs, functions, and benefits, wherein increased value can be achieved through optimizing functions without increasing expenses. In construction projects, value engineering plays a crucial role in controlling budgets, reducing resource waste, and preventing cost overruns by selecting more efficient design alternatives or implementation methods (Li et al., 2021). With a systematic process, value engineering also encourages innovation and multidisciplinary-based decisions so that projects can be completed more economically, effectively, and in accordance with the required quality standards.

In line with the concept of value engineering described above, several previous studies have demonstrated that the application of value engineering in educational building projects can result in significant cost savings without reducing building function or performance. Meilasari et al. (2023) applied value engineering to the architectural work of a public facility building and reported cost savings of approximately 3.12%, achieved through material substitution and design optimization. Elhegazy (2022) reviewed multiple value engineering applications in multi-story buildings, including educational facilities, and found that cost efficiencies generally ranged between 2% and 10%, depending on the scope and project stage. Similarly, Li et al. (2021) demonstrated that integrating value engineering with design evaluation techniques enabled construction projects to reduce unnecessary costs while maintaining quality standards, with reported savings of up to 5%. These findings confirm that value engineering is an effective approach for improving cost efficiency in school building projects and support its application in the Padang Sambian 1 Public Elementary School construction project.

3. METHODOLOGY

The implementation of the Value Engineering method is divided into several stages of analysis, referred to as the Value Engineering job plan, which is divided into the following phases.

3.1. Information stage

The information stage identifies high-cost work items with the potential to be the focus of value engineering. This process is carried out by compiling a breakdown cost model to group and sort work items based on cost, such that a cumulative percentage is obtained, which is then used to create a Pareto distribution chart to determine work items that contribute approximately 80% of the total cost. Next, a functional analysis is carried out using a FAST Diagram to map the basic and supporting functions of each work item, so that the boundaries and scope of alternative replacements in the creative stage can be determined in a more targeted manner.

3.2. Creative stage

The creative stage involves identifying various alternatives to the work identified in the information stage. Alternatives are obtained through discussions with relevant parties in the field, considering component changes that still meet basic functions and technical requirements, and outlining the work items and their functions to determine the most feasible replacement options.

3.3. Analysis stage

The analysis phase includes structural evaluation, advantages and disadvantages, costs, and alternative selection. Alternatives generated from the creative phase are first tested for compliance with product specifications and functions, including structural analysis using ETABS if the alternatives affect

building design. Next, a cost analysis was conducted by comparing the planned costs for each alternative. Alternative selection was carried out using an evaluation matrix based on criteria such as function, cost, and ease of implementation, with the assessment supported by discussions with field personnel. The alternative with the highest score then becomes the basis for the recommendations.

3.4. Recommendation stage

In the recommendation stage, recommendations are made based on the selected alternatives. These recommendations present the advantages of the chosen alternative and the amount of cost savings achieved. At this stage, the presentation of data may be displayed using tables. The table consists of work items, a description of the original design, the cost of the original design, a description of the replacement design, the cost of the replacement design, and the total savings obtained.

4. RESULT AND DISCUSSION

4.1. Information stage

In this stage, work items with the highest potential for Value Engineering analysis are identified. A breakdown cost model is used to classify costs and determine each item's contribution to the total budget, followed by ranking the items from highest to lowest cost to focus the analysis effectively. The ranked data are then plotted as a Pareto chart to establish priority items that dominate project expenses. After identifying these priorities, a functional analysis using the FAST Diagram is conducted to examine the relationship between primary and supporting functions, allowing the identification of tasks that can be modified, substituted, or simplified. This systematic approach ensures that Value Engineering produces more economical and efficient alternatives without compromising building quality (see Table 1).

Table 1. Breaking cost modelling

No	Job description	Total Cost (IDR)	Percentage (%)	Cumulative (%)
1	2nd Floor Concrete Work	1,595,423,994.03	15.92%	15.92%
2	3rd Floor Concrete Work	1,423,179,809.47	14.20%	30.13%
3	First Floor Concrete Work	1,062,698,441.90	10.61%	40.73%
4	Truss Work, Wooden Listplank and Roof Tiles	623,456,951.49	6.22%	46.96%
5	Foundation Work	539,668,305.71	5.39%	52.34%
6	Door, Window, Hanging and Locking Work	361,577,238.20	3.61%	55.95%
7	Masonry and Plastering Work	328,080,807.63	3.27%	59.23%
8	Masonry and Plastering Work	291,145,602.97	2.91%	62.13%
9	Door, Window, Hanging and Locking Work	289,650,518.52	2.89%	65.02%
10	Door, Window, Hanging and Locking Work	287,429,722.49	2.87%	67.89%
11	Masonry and Plastering Work	222,255,200.26	2.22%	70.11%
12	Paving Block Pair	189,015,152.91	1.89%	72.00%
13	Roof Concrete Work	179,078,647.39	1.79%	73.78%
14	Ceramic Floor and Wall Pair	179,018,109.09	1.79%	75.57%
15	Ceramic Floor and Wall Pair	178,053,976.39	1.78%	77.35%
16	3rd Floor Ceiling Work	172,893,959.87	1.73%	79.07%

| 17	Ceramic Floor and Wall Pair	170,839,754.61	1.71%	80.78%
18	Ceiling Work	135,150,837.32	1.35%	82.13%
19	Ceiling Work	135,150,837.32	1.35%	83.48%
20	Concrete Channel Work F'c 15 Mpa	127,089,153.05	1.27%	84.74%
21	Iron Works	119,297,223.79	1.19%	85.93%
22	Iron Works	118,167,691.11	1.18%	87.11%
23	Bali Style Jobs	116,815,518.59	1.17%	88.28%
24	Bali Style Jobs	116,815,518.59	1.17%	89.45%
25	Bali Style Jobs	116,815,518.59	1.17%	90.61%
26	Excavation and Filling Work	115,671,998.94	1.15%	91.77%
27	Painting and Waterproofing Work	98,776,230.54	0.99%	92.75%
28	Painting and Waterproofing Work	93,229,791.03	0.93%	93.68%
29	Iron Works	90,038,925.70	0.90%	94.58%
30	Painting Job	86,051,069.77	0.86%	95.44%
31	Yard Sink Job	71,581,797.27	0.71%	96.15%
32	Well Drilling, Pump and Water Tank Work	48,378,913.20	0.48%	96.64%
33	Electrical Installation Work	47,585,430.55	0.47%	97.11%
34	Electrical Installation Work	43,476,502.53	0.43%	97.55%
35	Electrical Installation Work	41,136,079.15	0.41%	97.96%
36	Water, Waste and Sanitation Installation Work	37,472,899.59	0.37%	98.33%
37	Lightning Rod Couple	31,690,980.75	0.32%	98.65%
38	Limestone Filling Work for Yard Raising	29,346,255.60	0.29%	98.94%
39	Measurement Work	24,716,219.61	0.25%	99.19%
40	Painting and Waterproofing Work	19,498,325.89	0.19%	99.38%
41	Final Cleaning Work	16,294,153.54	0.16%	99.54%
42	Preparatory work	15,268,067.70	0.15%	99.70%
43	Electrical Work	13,843,493.88	0.14%	99.83%
44	Water, Waste and Sanitation Installation Work	8,331,253.77	0.08%	99.92%
45	Water, Waste and Sanitation Installation Work	8,331,253.77	0.08%	100.00%
46	Floor 1 Work	-	0.00%	100.00%
47	2nd Floor Work	-	0.00%	100.00%
48	3rd Floor Work	-	0.00%	100.00%
49	Roofing Work		0.00%	100.00%
50	Other Jobs		0.00%	100.00%
	Total	**10,019,488,134.11**		
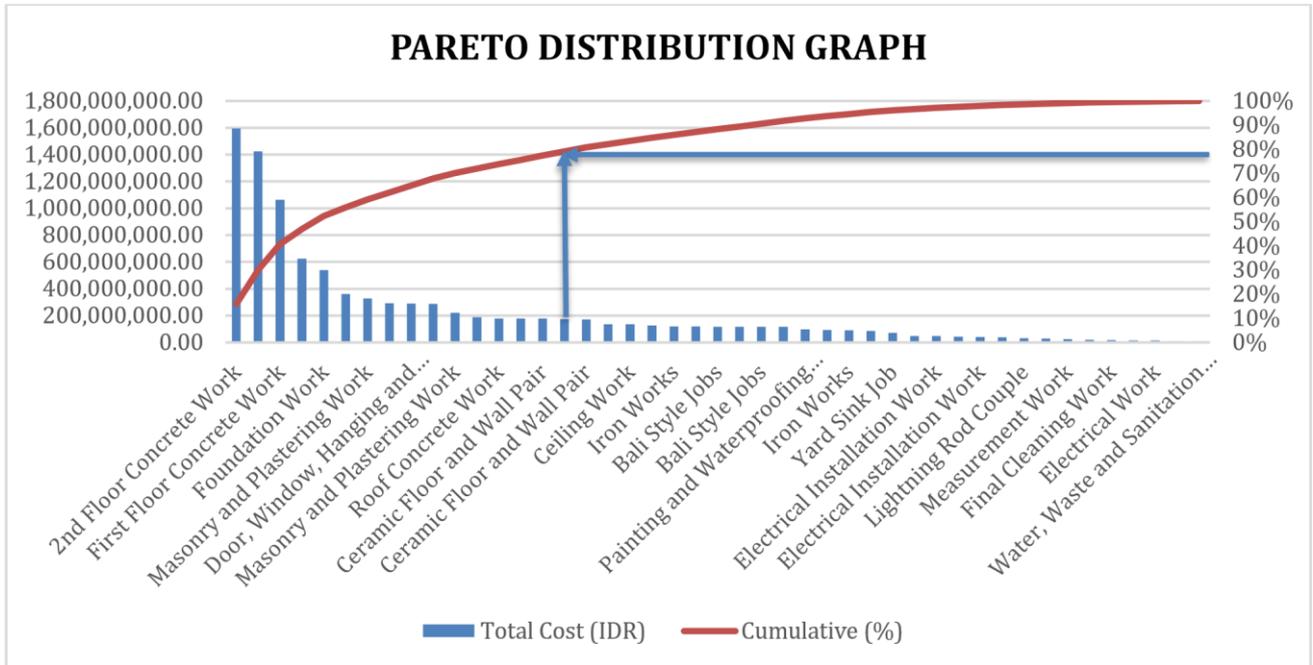
Figure 1. Pareto Distribution Graph

The Pareto chart in Figure 1 shows which work items account for 80% of the total costs of the work selected in the previous stage. These work items include: (1) concrete work on floors 1, 2, 3 and roof, (2) truss work, wooden planks and roof tiles (roof work), (3) door window hanging and locking work on floors 1, 2 & 3, (4) masonry and plastering work for floors 1, 2 & 3, (5) paving block pair, (6) ceramic floor and wall pair, and (7) 3rd floor ceiling work.

Earthworks and foundations were not considered in the analysis because of the problem limitations. Subsequently, in the functional analysis stage, using the FAST diagram is useful for outlining studies and analyses that refer to the function of the scope of the work items being studied, which will later be used as a reference for developing alternatives in the next stage. Functional analysis using the FAST diagram was performed on each work item selected based on the Pareto diagram.

For clarity, see Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8.
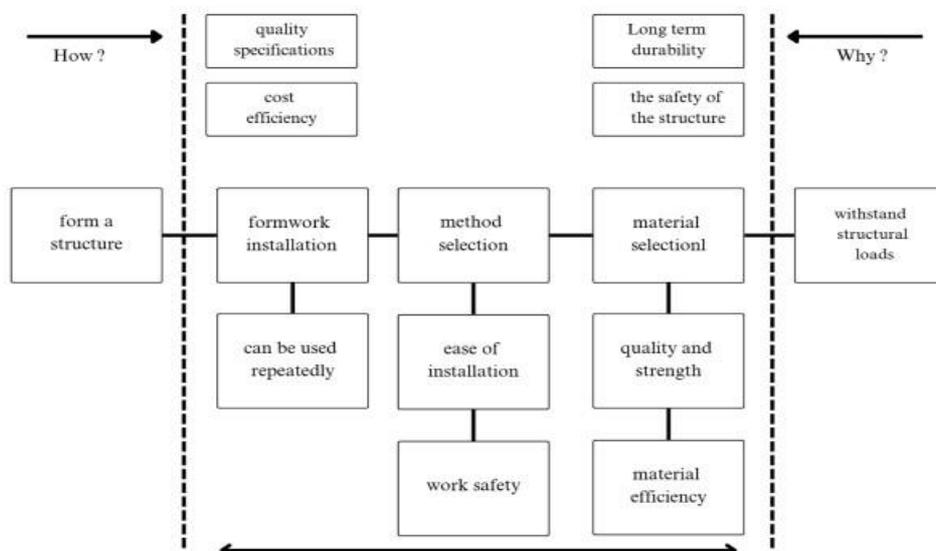

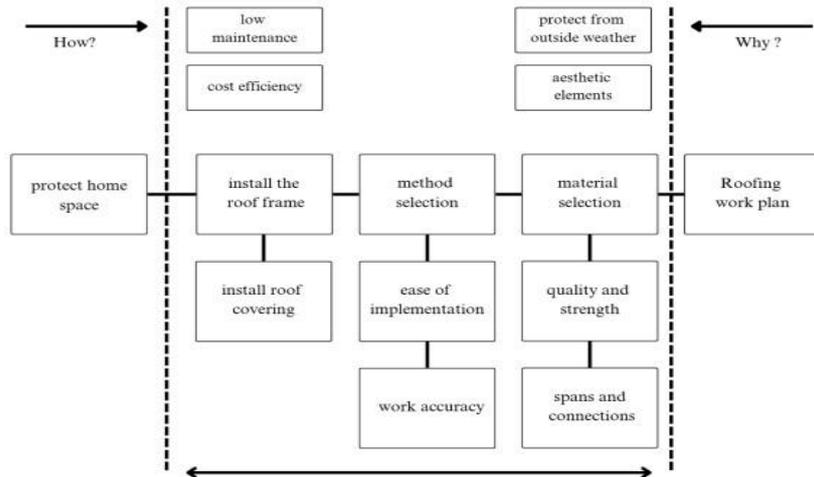**Figure 2. FAST Diagram of Concrete Work on Floors 1, 2, 3 and Roof**
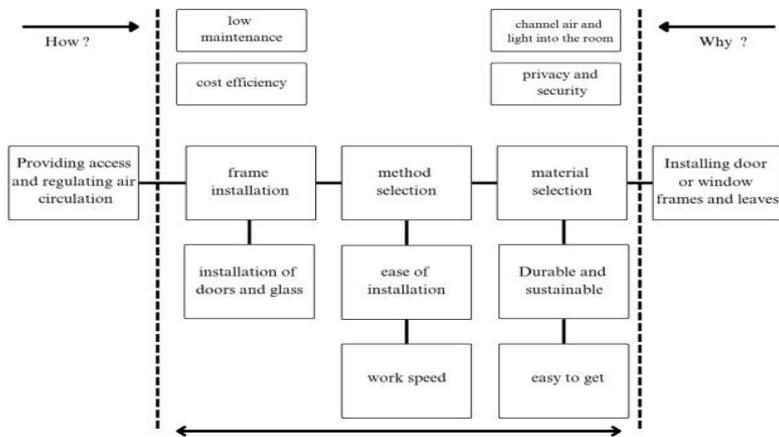
Figure 3. FAST Diagram of Roofing Work

Figure 4. FAST Diagram on door window hanging and locking work
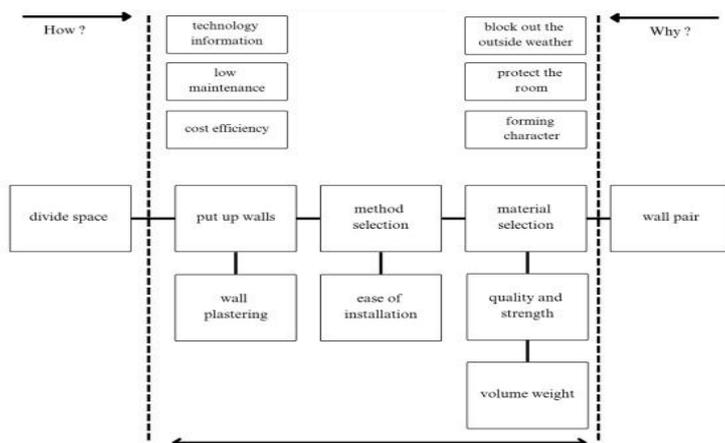
Figure 5. FAST Diagram of masonry and plastering work on floors 1, 2 & 3
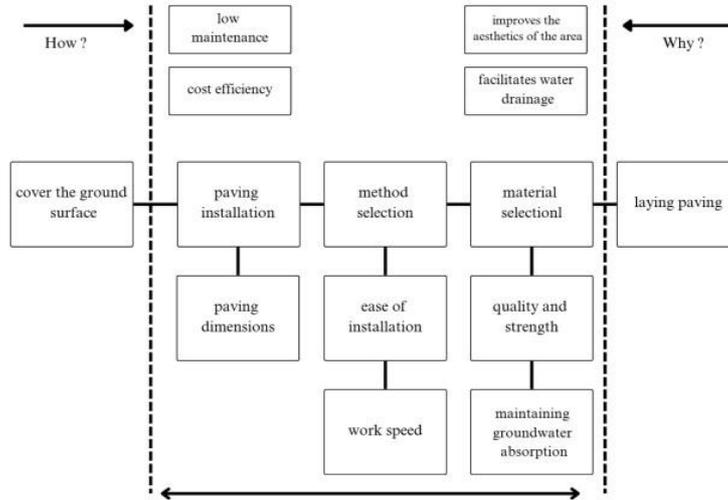
Figure 6. FAST Diagram of Paving Block Pairs
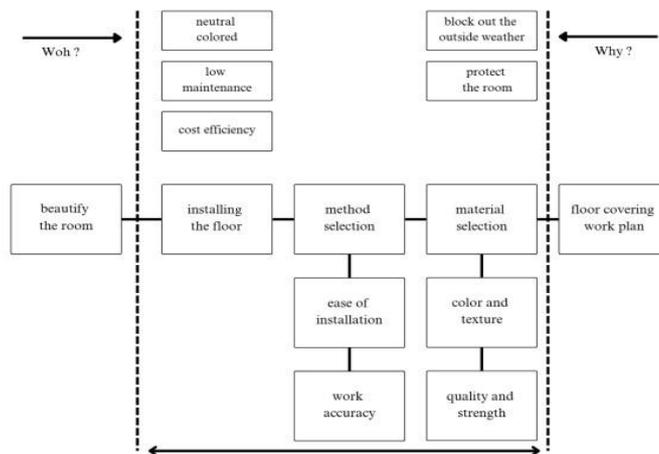
Figure 7. FAST Diagram of ceramic floor and wall pairs
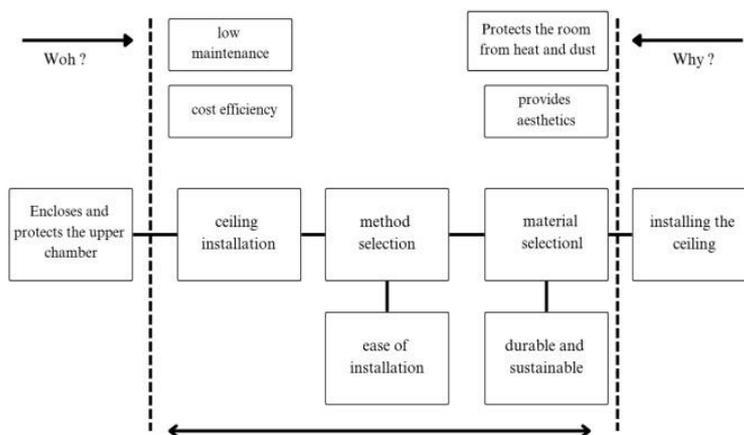
Figure 8. FAST Diagram of 3rd floor ceiling work

4.2. Creative stage

The creative phase of Value Engineering is the process of searching for design alternatives with the goal of producing solutions that fulfill the primary function of the construction project while providing cost efficiency without compromising technical quality standards. At this stage, each project is analyzed

based on its basic function and objective function as described in the FAST Diagram. Through this approach, each alternative generated adheres to the structural requirements, aesthetics, safety, and ease of maintenance.

For the concrete work on the first, second, and third floors, as well as the roof, the creative phase yielded several alternatives, including reducing the column dimensions, reducing the number of columns, and replacing the material with steel. After conducting functional and technical analyses, reducing the dimensions of columns K1 and K2 by 100 mm per column was selected as the best alternative because it reduced the concrete volume without changing the structural system. This solution maintained the standard load capacity and supported efficient implementation in the field (Stefanuto & Focant, 2020).

For the roofing work, particularly on the truss elements, the creative phase evaluated alternative lightweight steel materials from several profile types. The chosen alternative was C 75/075 Profile Light Steel, which was considered more economical, had adequate strength, was easy to install, and fulfilled the primary function of roofing work in protecting the space from the weather (Liu et al., 2023). This selection also considered cost efficiency and ease of long-term maintenance.

Alternatives developed for doors, windows, hangers, and locks included the use of aluminum and teak wood frames. Based on a functional and cost analysis, aluminum frames were chosen as the best alternative because of their greater resistance to corrosion, termites, and weather changes (Partuti et al., 2022). Furthermore, this material requires minimal maintenance, is easy to install, and boasts good stability, ensuring long-term building efficiency.

The creative phase of the masonry and plastering work resulted in two main alternatives: the use of lightweight bricks and the application of a 1 Pc:5 Ps plaster mixture with a thickness of 15 mm. The plaster alternative was chosen because it is more economical, easier to apply, and provides consistent quality. Using a single mixture also simplifies the implementation process and minimizes maintenance requirements, thus meeting the established efficiency goals.

In the ceramic floor and wall work, the creative stage evaluated the alternatives between using 30x30 cm ceramic tiles and 60x60 cm granite tiles. Based on a functional and cost analysis, 30×30 cm ceramic tiles were chosen because they are more economical, easy to install, and have adequate strength for classroom areas and medium-activity areas. This material also has low maintenance and is quick to install, thus aligning with the efficiency goals formulated in the FAST Diagram.

During the paving block installation project, several alternatives were compared, including 6 cm thick K225 grade paving and cast concrete pavement. The evaluation results indicated that 6 cm thick paving was more suitable because the project requirements did not require heavy vehicle support. Furthermore, the paving material was easier to install, more economical, and sufficiently strong for pedestrian activities and normal use in school areas. Ease of maintenance was also a key consideration in the selection.

For the third-floor ceiling project, the alternatives developed included gypsum board, PVC panels, and GRC boards. After evaluation, the gypsum board ceiling was chosen as the most optimal alternative because of its lower cost, quick installation, and neat and modern final appearance. This material also meets the required functional standards, including aesthetics, safety, and ease of maintenance, thus aligning with the efficiency goals of the Value Engineering creative stage.

4.3. Analysis stage

In this analysis stage, each alternative proposed in the creative stage was analyzed. These analyses included structural analysis, job cost analysis, and alternative selection analysis.

4.3.1. Structural Analysis

A structural analysis was conducted using the ETABS application with reference to the design details in the attached working drawings. Based on the previous creative stage, the selected alternative was to reduce the dimensions of columns K1 and K2 from 450 mm × 450 mm and 350 mm ×350 mm to 400 mm × 400 mm and 300 mm ×300 mm, respectively. These alternative dimensions were then modeled and analyzed using ETABS. The frame and plate input data are listed in Table 2 and Table 3.

Table 2. Breaking cost modelling

Code	Dimensions (mm)	Main Reinforcement (mm)	Stirrup Reinforcement (mm)
K1	400/400	16 – D19	D10 – 100
K2	300/300	12 – D16	D10 - 100
K3	350/350	8 – D19	D10 - 100
K4	350/350	8 – D16	D10 - 100
B1	600/300	6 – D16	D10 - 100
B2	400/250	4 – D16	D10 - 100
B3	400/250	6 – D16	D10 - 100
RB	300/200	3 – D16	D10 - 100
S1	450/250	3 – D16	D10 - 100
S2	250/100	2 – D16	D10 - 100
Plate 1	Thickness 100	D10 - 150	
Plate 2	Thickness 120	D10 - 150	
Plate 3	Thickness 150	Ø8 - 250	

Table 3. Structural load

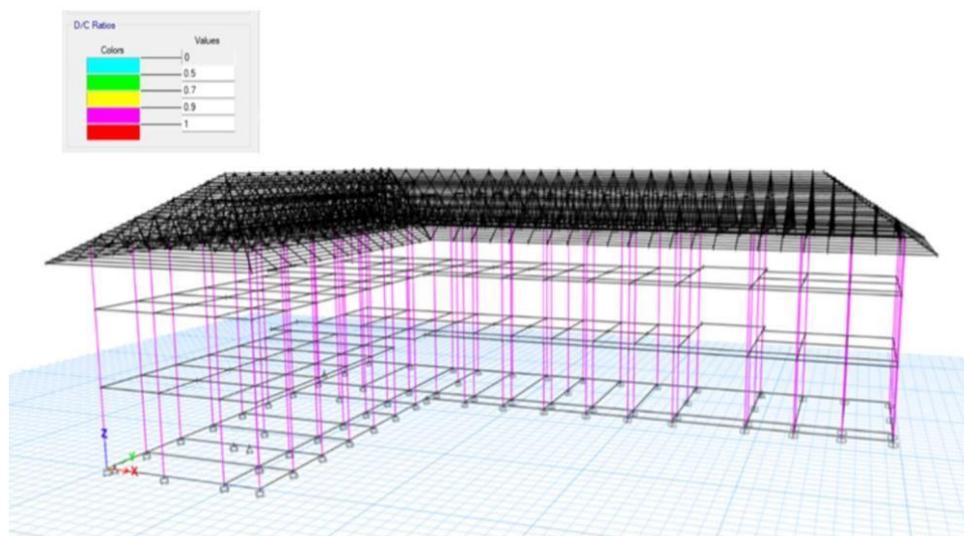| Load Name	Type	Magnitude	Unit
Wall load	*Superdead*	16.5	Kn/m
Live load of floor slabs for school buildings	*Live*	1.92	Kn/m
The dead load for a maximum plate thickness is 150 cm	*Superdead*	4.4	Kn/m
Earthquake load	*Quake*	*Autoload*	Kn/m

Figure 9. Alternative Structure Model Run Results

As shown in Figure 9, all structural elements exhibited stress ratio values of less than 1.0. Column elements are marked in purple and beam elements in black, indicating no overstress in the structural components (Pechorskaya et al., 2021). Therefore, all elements were deemed safe to withstand the working load. The analysis was then continued by calculating the cost changes resulting from column dimension adjustments.

4.2. Job Cost Analysis

At this stage, each alternative is evaluated in terms of cost efficiency to determine whether design changes can provide significant savings and the cost comparison also ensures that the selected alternative truly provides added value according to Value Engineering principles.

4.2.1. Concrete work on floors 1, 2, 3 and roof

For clarity, see Table 4.

Table 4. Comparison table of planned costs with alternative costs for concrete work on floors 1 and 2

Concrete column plan for floors 1 and 2	Total Price (IDR)
Concrete work for columns K1 450mm x 450mm and K2 350mm x 350mm, floors 1 and 2	450,248,304.08
Alternative concrete columns for floors 1 and 2	**Total Price (IDR)**
Concrete work for columns K1 400mm x 400mm and K2 300mm x 300mm, floors 1 and 2	381,022,096.83

The alternative cost of concrete work for the 1st and 2nd floor structures compared to the planned cost of concrete work for the 1st and 2nd floor structure columns resulted in cost savings of the IDR. 69,226,207.23.

4.2.2. Truss work, wooden planks and roof tiles (roof work)

For clarity, see Table 5.

Table 5. Comparison table of planned costs with alternative costs for roofing work

Roof work plan	Total Price (IDR)
Light Steel Frame, UK 75 Profile (Karangpilang Frog Roof Tiles) + Inner Gutter	332,131,843.99
Alternative roofing work	**Total Price (IDR)**
Light Steel Frame, C 75 Profile (Karangpilang Frog Roof Tiles) + Inner Gutter	274,116,217.13

The alternative roofing costs were then compared with the planned roofing costs, resulting in cost savings for the IDR. 58,015,626.87.

4.2.3. Door window hanging and locking work

For clarity, see Table 6.

Table 6. Comparison of planned costs with alternative costs for door, window, hanging, and locking work

Work plan for door, window, hanging and locking	Total Price (IDR)
Installation work of camphor wood door frames for floors 1, 2, and 3	38,619,896.07
Alternative work of door window hanging and locking	**Total Price (IDR)**
Installation work of aluminum door frames for floors 1, 2, and 3	31,729,007.19

The alternative costs were then compared with the planned costs, resulting in cost savings of IDR 6, 890, 888.88. 6,890,888.88.

4.2.4. Masonry and plastering work (wall work)

For clarity, see Table 7.

Table 7. Comparison table of planned costs with alternative costs for wall work

Wall work plan	Total Price (IDR)
Plastering work with 3 types of mixtures, namely 1 Pc: 5 Ps 15 Mm Thickness, 1 Pc: 3 Ps 15 Mm Thickness, 1 Pc: 2 Ps 15 Mm Thickness for floors 1, 2, and 3	396,316,661.90
Alternative wall work	**Total Price (IDR)**
Plastering work with 1 type of mixture, namely 1 Pc: 5 Ps 15 Mm Thick, for floors 1, 2, and 3	395,156,564.28

Alternative costs were then compared with the planned costs, resulting in cost savings for the IDR. 1,160,097.63.

4.2.5. Pair of paving blocks

For clarity, see Table 8.

Table 8. Comparison table of planned costs with alternative costs for paving block work

Paving block pairing plan	Total Price (IDR)
Fit. Paving 20 X 20 Cm Thickness 8 Cm K225	167,256,129.06
Alternative paving block pairs	**Total Price (IDR)**
Fit. Paving 20 X 20 Cm Thickness 6 Cm K225	118,694,621.85

Alternative costs were then compared with the planned costs, resulting in cost savings for the IDR. 48,561,507.2.

4.2.6. Ceramic floor and wall pairing
For clarity, see Table 9.

Table 9. Comparison table of planned costs with alternative costs for ceramic floor work

Plan for ceramic floor and wall tiles	Total Price (IDR)
40 X 40 Cm Ceramic Floor Work with Smooth and Rough Surfaces for Floors 1, 2, and 3	416,836,181.22
Alternative ceramic floor and wall pairs	**Total Price (IDR)**
30 X 30 Cm Ceramic Floor Work with Smooth and Rough Surfaces for Floors 1, 2, and 3	398,307,920.98

The alternative costs were then compared with the planned costs, resulting in cost savings of IDR. 18,528,260.2.

4.2.7. 3rd floor ceiling work
For more clarity, see Table 10.

Table 10. Comparison table of planned costs with alternative costs for 3rd floor ceiling work

3rd floor ceiling work plan	Total Price (IDR)
Semi Meranti Plywood Ceiling Work 6 Mm Thick, Hollow Frame with Camphor Wood Strips	172,893,959.87
Alternative work on the 3rd floor ceiling	**Total Price (IDR)**
Gypsum Ceiling work, Hollow Frame, with 5X5 Cm Gypsum Ceiling list	150,710,456.53

The alternative costs were then compared with the planned costs, resulting in cost savings of IDR. 22,183,503.3.

4.3. Alternative Selection Analysis

4.3.1. Concrete work
Table 11. Evaluation Matrix of Structural Job Alternatives

Criteria	Design plan	Alternative design
Strength	1	1
Cost	1	2
Implementation	1	2
Total	**3**	**5**

As shown in Table 11, the alternative design received a higher score than the planned design because the costs required were lower, and in terms of implementation, the reduction in dimensions that had been applied in the creative stage could result in a much faster work implementation process.

4.3.2. Truss work, wooden planks and roof tiles (roof work)

Table 12. Evaluation Matrix of Roof Truss Work Alternatives

Criteria	Design plan	Alternative design
Strength	2	1
Cost	1	2
Implementation	1	2
Total	**4**	**5**

As indicated in Table 12, the alternative design received a higher score than the planned design because the required costs were lower, although the alternative design exhibited a slight difference in strength. However, in terms of implementation, the installation of the C 75 profile light steel truss is significantly faster and easier.

4.3.3. Door window hanging and locking work

Table 13. Evaluation Matrix for Alternative Door and Window Hanging and Locking Work

Criteria	Design plan	Alternative design
Strength	1	2
Cost	1	2
Implementation	1	2
Total	**3**	**6**

As shown in Table 13, the alternative design received a higher score than the planned design because, in every criterion in terms of strength, cost, and implementation, the alternative design was far superior to the planned design.

4.3.4. Masonry and plastering work (wall work)

Table 14. Alternative Evaluation Matrix for Masonry and Plastering Work

Criteria	Design plan	Alternative design
Strength	2	1
Cost	1	2
Implementation	1	2
Total	**4**	**5**

As can be seen in Table 14, the alternative design gets a higher score than the planned design because the costs required are less, although in terms of strength the alternative design has a slight difference, but in terms of implementation, the 1 Pc: 5 Ps 15 Mm Thickness mixture is much faster and easier.

4.3.5. Paving block pair

For clarity, see Table 15.

Table 15. Evaluation Matrix for Alternative Paving Block Work

Criteria	Design plan	Alternative design
Strength	2	1
Cost	1	2
Implementation	1	2
Total	**4**	**5**

Based on the analysis results in the comparison table between the planned design using 8 cm thick paving and the alternative design with 6 cm thick paving, it can be seen that the alternative design obtained a total score of 5, higher than the planned design which obtained 4. Although the planned design is superior in terms of strength, the alternative design is superior in terms of cost and implementation criteria. The combination of more economical costs and more efficient implementation makes the alternative design a more optimal choice for this job condition.

4.3.6. Ceramic floor and wall pairing
For clarity, see Table 16.

Table 16. Evaluation Matrix of Alternative Ceramic Floor and Wall Work

Criteria	Design plan	Alternative design
Strength	1	2
Cost	1	2
Implementation	2	1
Total	**4**	**5**

Based on the analysis results in the evaluation matrix table, the alternative design received a higher total score. This was primarily because of the alternative design 's superior strength and cost efficiency. Although the planned design is superior in terms of ease of implementation, overall, the alternative design is considered more optimal and offers better benefits for implementation.

4.3.7. 3rd floor ceiling work
For clarity, see Table 17.

Table 17. Evaluation Matrix of Alternative Work for the 3rd Floor Ceiling

Criteria	Design plan	Alternative design
Strength	2	1
Cost	1	2
Implementation	1	2
Total	**4**	**5**

Based on the analysis results in the evaluation matrix table, the alternative design received a higher total score. The design plan was slightly superior in terms of strength, but the alternative design demonstrated more significant advantages in terms of cost and implementation. The combination of cost efficiency and ease of execution made the alternative design the optimal choice.

4.4 Recommendation stage
At this stage, new design recommendations are made based on the selected alternatives. A comparison between the planned design and the alternative designs is explained below.

Based on the cost analysis results, several alternatives are recommended to improve project efficiency. In the concrete work of floors 1, 2, 3, and the roof, reducing the dimensions of column K1 from 450×450 mm to 400×400 mm and K2 from 350×350 mm to 300×300 mm resulted in savings of IDR69,226,207.23. In the roof work, the use of light steel frame profile C 75/075 instead of UK 75/075 resulted in savings of IDR58,015,626.87. In the door and window work, replacing camphor wood frames with aluminum resulted in savings of IDR6,890,888.88. For masonry and wall plastering work, the application of one type of plaster mixture 1Pc:5Ps 15 mm thick resulted in savings of IDR1,160,097.63. In paving block work, the use of 6 cm K225 paving instead of 8 cm K225 paving provides savings of IDR48,561,507.20. In floor and wall work, the use of 30×30 cm ceramic tiles as an alternative to 40×40

cm ceramic tiles results in savings of IDR18,528,260.20. Finally, in the 3rd floor ceiling work, the use of gypsum instead of plywood provides savings of IDR22,183,503.30. Overall, these alternatives are proven to provide cost efficiency without reducing the function and quality of the work.

5. CONCLUSION

Based on the Value Engineering analysis of the Padang Sambian 1 Elementary School Building Construction Project, several important conclusions were obtained. A number of work items that are considered to have potential savings, namely column concrete work, roof work, doors and windows including hangers and locks, wall masonry and plastering, paving block masonry, ceramic floors and walls, and the 3rd floor ceiling. The alternatives with the lowest costs selected include reducing the dimensions of the K1 and K2 Structure columns with evaporation of IDR 69,226,207.23, the use of C75 profile light steel trusses with drying of IDR 58,015,626.87, the use of aluminum frames on doors and windows with savings of IDR 6,890,888.88, the application of a 1Pc:5Ps mixture with a thickness of 15 mm on the masonry and plastering of walls with savings of IDR 1,160,097.63, the use of 20×20 cm paving with a thickness of 6 cm K225 with savings of IDR 48,561,507.20, the use of 30×30 cm ceramics for floors and walls with savings of IDR 18,528,260.20, and the use of gypsum ceilings on the 3rd floor with savings of IDR 22,183,503.30. Overall, the total savings achieved reached IDR 224,566,091.39 or 2.24% of the total project cost.

Ethical Approval

Ethical approval was not required since the study involved only field observations of parking behavior without collecting personal or sensitive data. All research activities complied with ethical research standards.

Informed Consent Statement

Informed consent was not applicable because no individual information was gathered. Data were limited to vehicle counts and parking occupancy in public areas.

Authors' Contributions

Conceptualization and methodology, I.N.I.K. and R.M.; validation and supervision, D.A.T.A.W. and D.I.C.; writing original draft, R.M.; writing, review, and editing, R.M. and I.N.I.K. All authors approved the final manuscript.

Disclosure statement

The authors declare no conflict of interest related to this study.

Data Availability Statement

All data supporting this study are available from the corresponding author upon reasonable request.

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This research received able to reduce project costs without reducing the function, quality and performance of the building, while providing a more efficient technical basis for decision making at the planning and construction implementation stages.

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