



The Application of the Multi-Criteria Decision-Making Method as an Alternative Selection for Structural Work with the Concept of Green Construction

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Abstract. The construction sector is a significant contributor to carbon emissions, high energy consumption, and excessive exploitation of natural resources. Sustainable construction offers a solution to reduce environmental impact while maintaining efficiency and sustainability. This study focuses on optimizing wall construction costs through value engineering (VE) based on sustainable construction principles. The research was conducted at the Sumitra Hotel and Resort project in Bali, Indonesia, where conventional wall construction methods led to cost inefficiencies. A descriptive quantitative approach was used, with primary data collected through surveys and interviews, and secondary data from the project's budget plan (RAB) and unit cost analysis (AHSP). The VE methodology included information gathering, functional analysis, creative phase, evaluation, development, and recommendation. The results identified interlock bricks as the optimal alternative, reducing costs by IDR 84,633,730 (5.16% of the initial budget) while adhering to sustainability criteria. This study demonstrates the potential of VE to enhance cost efficiency in construction projects without compromising quality or environmental goals.

Keywords: Alternative, Structure, Value, Wall

1 Introduction

The construction industry is responsible for substantial carbon emissions, energy consumption, and environmental degradation (Kimsan, 2023). Sustainable construction has emerged as a solution that balances economic, social, and environmental aspects (Willar, 2019). However, challenges such as high costs, limited technical knowledge, and inefficient methods hinder its implementation (Willar & Trigunaryah, 2021). Wall construction is a critical component of building projects, significantly impacting budgets and timelines (Rani et al., 2025). Conventional methods, such as red brick or lightweight brick walls, often incur high costs and prolonged execution times (Sadilah et al., 2023). Modular systems and innovative materials, such as interlock bricks, offer potential savings but require careful evaluation (Setyawan & Pakpahan, 2024). In addition, there is a difference in the cost of wall construction depending on the type of

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material used. For example, the use of lightweight bricks is more expensive than concrete blocks, but superior in terms of installation time. Red bricks are cheaper in cost, although they require a longer installation time (Musyafa & Iqbal Adie Surya Firdaus, 2023). The primary concern is selecting wall construction methods and materials that strike an optimal balance between cost and time efficiency, without compromising overall construction quality. Therefore, an in-depth analysis of various wall construction alternatives is essential to optimize the project budget and ensure sustainable development through value engineering. This study addresses the problem of cost inefficiency in wall construction at the Sumitra Hotel and Resort project by applying value engineering (VE) principles rooted in sustainable construction. VE identifies unnecessary costs and proposes alternatives without compromising quality (Yusuf et al., 2021). The research purpose is to find alternative materials that can replace the initial wall design while adhering to sustainable construction, and to determine the cost optimization can be achieved through VE.

2 Methodology

The study uses a descriptive quantitative approach. Data collection encompasses both primary data, such as surveys of material prices and interviews with project managers, and secondary data, including RAB, AHSP, and project schedules. The research stages are presented in the following image:

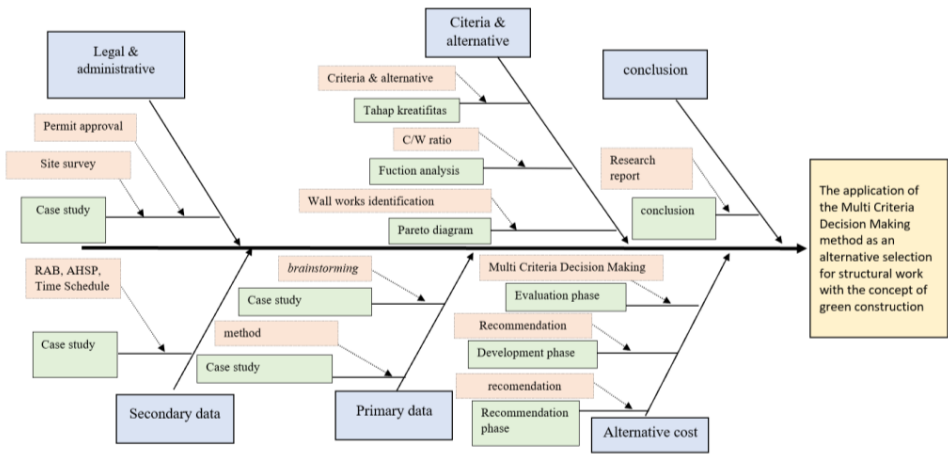


Figure 1. Fishbone Diagram

The VE process follows six phases (Nandito et al., 2020) beginning with the information phase, which identifies high-cost items using pareto analysis (Saori et al., 2021) followed by the function analysis: evaluate functions and cost-to-worth ratios (C/W); creative phase: generate alternatives (e.g., interlock bricks, precast panels); evaluation phase: select the best alternative using multi-criteria decision making

(MCDM); development phase: calculate life-cycle costs for the chosen alternative; and finally, the recommendation phase: present findings and cost savings.

3 Result and Discussion

3.1 Result

Information Phase. During the information phase, the work items contributing the highest costs to the total budget are identified, along with their primary functions, using a Cost Model. Following this determination, high-value work items with the most significant cost contributions are further analyzed through Pareto diagram identification.

Table 1. Cost model

No	Work item	Main Function	Cost (IDR)	%
1	Site Preparation	Initial condition preparation	4,933,569,567	19 %
2	Structural work	Building support	11,833,189,764	45 %
3	Doors & Windows	Circulation and access	3,310,368,800	13 %
4	Finishing Work	Aesthetics and comfort	2,939,973,729	11 %
5	External work	Aesthetics and environment	3,067,179,079	12 %

From Table 1, structural work accounts for 45% of the total budget (IDR 11.83 billion), indicating its dominance in cost allocation. Pareto analysis should prioritize structural work for value engineering. Following the identification of structural work items targeted for optimization, the next phase involves pinpointing the most influential structural components through Pareto analysis. From Table 2 dan Figure 2, the Pareto diagram operates on the 80/20 principle, where 80% of outcomes typically arise from 20% of causes. For the structural work components, the analysis yielded a prioritized ranking of work items from highest to lowest impact value, presented below in both tabular and graphical formats:

Table 2. Percentage of Work Value from Highest to Lowest

No	Work item	Total Amount (IDR)	%	Cumulative %
1	Upper Structure work	7,264,097,881	61 %	61 %
2	Wall Work	1,640,441,936	14 %	75 %
3	Roof Work	1,087,962,531	9 %	84 %
4	Lower Structure Work	993,507,988	8 %	93 %
5	Earth Work	495,630,299	4 %	97 %
6	Miscellaneous Work	351,549,129	3 %	100 %

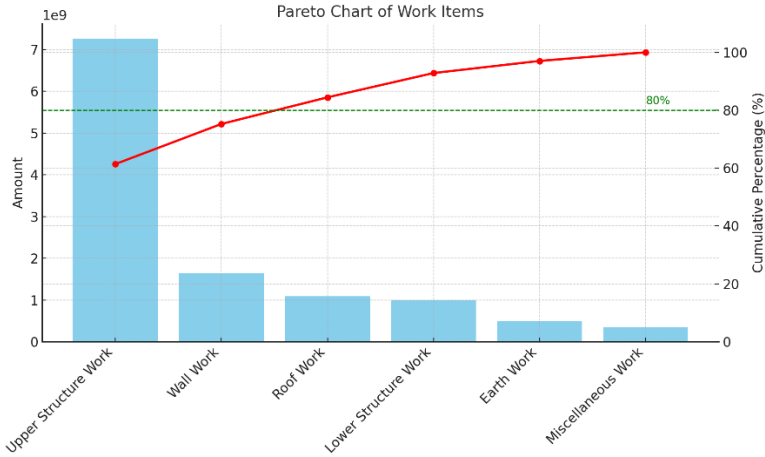


Figure 2. Pareto Chart

Function Analysis Phase. After identifying the primary and secondary functions, the analysis proceeds with determining the Cost-to-Worth Ratio (C/W Ratio). According to Table 3, the wall construction work exhibits a significant cost disparity of IDR 85,735,685, resulting in a C/W Ratio of 1.06. Consequently, the wall construction has been identified as requiring further value engineering (VE) analysis.

Table 3. Function and C/W Ratio

No	Work item	Main Function	Cost (IDR)	Estimate worth (IDR)	C/W Ratio
1	Upper Structure work	Supporting upper load	7,264,097,881	7,250,492,774	1.00
2	Wall Work	Dividing space	1,640,441,936	1,554,706,250	1.06

Creative Phase. Following the selection of wall construction items based on functional analysis and C/W Ratio evaluation, the process advances to generating alternative solutions through structured brainstorming sessions. Concurrently, evaluation criteria must be established to assess potential alternatives. These criteria should reflect material efficiency, environmental impact, constructability and maintainability, life-cycle cost, durability, and weather resistance.

The alternatives are gypsum board partition with metal stud framing, a lightweight precast concrete panel system, and an interlocking brick system (plaster-free).

Evaluation Phase. The evaluation phase serves to systematically assess and identify the optimal solution from all generated alternatives. This stage employs Multi-Criteria Decision-Making (MCDM) methodology. In this MCDM method, information is required in the form of alternatives, criteria, weights, scores, and final values. The

determination of weight values is carried out through brainstorming with project stakeholders to establish the importance ranking scale for each criterion. Then, the scoring of alternatives is conducted through a questionnaire using a Likert scale (1–5). The results of the MCDM evaluation can be seen in the following Table 4.

Table 4. MCDM Result Evaluation

Criteria	%	Alt 1	Alt 2	Alt 3	Alt 4
Criteria 1	20 %	4 (80)	3(60)	5(100)	3(60)
Criteria 2	20 %	3 (60)	3(60)	4(80)	5(100)
Criteria 3	20 %	5 (100)	3(60)	4(80)	4(80)
Criteria 4	20 %	4 (80)	4(80)	5(100)	5(100)
Criteria 5	20 %	3 (60)	4(80)	4(80)	4(80)
Average		76	68	88	84

Development Phase

Table 5. Unit Price Analysis for the Installation of 1 m² Interlock Wall

No	Description	Unit	Coefficient	Unit Price (IDR)	Total price (IDR)
A	Labor				
	Worker	OH	0.32	100,000	32,000
	Bricklayer	OH	0.12	150,000	18,000
	Foreman	OH	0.012	250,000	3,000
	Supervisor	OH	0.016	250,000	4,000
	Total Labor				57,000
B	Materials				
	Interlock brick	Pcs	40	5,500	220,000
	Portland Cement	Kg	18.2	1,100	20,020
	Sand	m ³	0.28	200,000	56,000
	Ø8 mm Anchor Steel	Kg	0.28	33,500	9,380
	Total Material				305,400
C	Overhead & Profit			10 %	36,240
	Total Amount (A+B+C)				398,640

Based on the calculation results in Table 5, the unit price for installing interlock brick walls per square meter is IDR 398,640. This value will then be multiplied by the wall work volume to obtain the total cost of the wall work.

Recommendation phase. The best alternative material to replace the original wall design for the Sumitra Hotel and Resort project, based on the analysis and aligned with sustainable construction principles, is the interlock brick wall (without plaster). The implementation cost for the interlocking brick wall system, with a total volume of 3,902.79 m² at a unit price of IDR 398,640, amounts to IDR 1,555,808,206. The results were compared with the initial budget to determine the cost optimization achieved for the wall construction.

Table 6. Cost Implementation Optimization

Initial cost (IDR)	Alternative cost (IDR)	Difference (IDR)	Optimization Percentage
1,640,441,936	1,555,808,206	84,633,730	5.16 %

According to Table 6, a cost-benefit analysis reveals a net saving of IDR 84.63 million (5.16%) when comparing the alternative wall system (IDR 1,555.81 million) to the original design (IDR 1,640.44 million).

3.2 Discussion

The Pareto analysis reveals a pronounced concentration of project costs in upper structure work, accounting for 61% of total expenditures (IDR 7.26 billion). This dominance suggests that value engineering efforts should prioritize structural components to achieve significant cost optimization, aligning with the Pareto principle (also known as the 80/20 rule), where a minority of items drive the majority of impacts. The Cost-to-Worth (C/W) ratio evaluation reveals critical insights into the value efficiency of construction components. Upper Structure Work demonstrates perfect value alignment with a C/W ratio of 1.00, indicating the estimated worth (IDR 7.25 billion) fully justifies its construction cost (IDR 7.26 billion). This suggests optimal resource allocation for its primary function of “supporting upper loads”. Wall Work shows a slight value deficit (C/W = 1.06), where costs (IDR 1.64 billion) exceed estimated worth (IDR 1.55 billion) by 6%. This disproportion for “space division” functionality identifies walls as a prime candidate for value engineering interventions. From the creative phase From the creative stage, the criteria and alternatives used in the analysis were identified. Through the evaluation stage using the MCDM method, the best alternative selected was the interlocking brick system. Interlocking bricks reduce costs by eliminating the need for plastering, minimizing waste, and shortening construction time. The 5.16% cost savings align with previous studies on VE in green building projects. Sustainable materials, such as interlock bricks, also lower long-term maintenance costs, supporting lifecycle efficiency.

4 Conclusion

The alternative material that can replace the original wall design for the Sumitra Hotel and Resort project, based on sustainable construction principles, is the interlocking brick wall (without plaster). The cost optimization achieved for the wall construction work, after applying value engineering to the Budget Plan (RAB), amounts to IDR 84,633,730 or 5.16% of the original wall construction cost.

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