Technema: Journal of Intelligent Engineering and Computing
Vol 1 No 3 September 2026, Hal 345-356
ISSN: 3163-6020 (Print) ISSN: 3163-5997 (Electronic)
Open Access: https://sovereignresearch.org/technema

Value Engineering Analysis of the Mutiara Kedungmundu Housing Project in Semarang City

Angga Sofyan Sugiarto[1*], Bagas Abimanyu[2], Kartono Wibowo[3], Eko Muliawan Satrio[4]
[1-4] Universitas Islam Sultan Agung, Semarang, Indonesia
email: sugiartoangga04@gmail.com[1]

Article Info :
Received:
09-08-2026
Revised:
26-08-2026
Accepted:
08-09-2026

Abstract

Housing development projects are required to achieve cost, quality, and time targets efficiently, creating a need for effective cost-control methods that do not compromise building function and quality. This study aims to identify more economical material alternatives and determine the potential cost savings from applying Value Engineering to the architectural works of the Mutiara Kedungmundu Housing Project in Semarang City. A case study approach was employed through four Value Engineering stages: information, creative, analysis, and recommendation. Data were obtained from the project's Bill of Quantities, Unit Price Analysis, and working drawings, and were analyzed using cost breakdown, Pareto analysis, function analysis based on Cost/Worth, Zero-One analysis, and an evaluation matrix. The results identified five architectural work items with high optimization potential, namely walls, door and window frames, floor and wall finishing, roof, and ceiling. Seven selected material alternatives reduced the architectural work cost from Rp155,832,330.69 to Rp144,998,247.48, generating a saving of Rp10,834,083.20 or 6.95% of the initial cost. The selected alternatives maintained the primary building functions, quality, and aesthetic requirements. These findings demonstrate that Value Engineering provides an effective systematic approach for optimizing construction costs in small- to medium-scale housing projects while maintaining essential building performance.

Keywords: *Building Materials, Cost Efficiency, Housing Project, Value Engineering, Value Optimization.*

©2026 Authors.. This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.
(https://creativecommons.org/licenses/by-nc/4.0/)

INTRODUCTION

Population growth and continuing urbanization have increased the demand for adequate, affordable, and functionally appropriate housing, making residential development an important component of contemporary urban construction, particularly in rapidly growing cities in developing countries. This condition has intensified the pressure on housing developers to provide residential products at competitive prices while maintaining construction quality, functional performance, occupant comfort, and architectural acceptability. At the project level, these competing requirements make cost, quality, and construction time interdependent dimensions of construction management that must be controlled simultaneously because changes in one dimension can influence the achievement of the others (Soeharto, 1995). Effective project management therefore requires decision-making that considers not only the initial construction expenditure but also the relationship between resources, technical requirements, and the functions delivered by each building component (Dimyati & Nurjaman, 2014). Recent developments in construction value engineering indicate that the discipline has increasingly shifted from a conventional cost-reduction technique toward a systematic approach for improving project value through functional analysis, alternative generation, and structured decision-making (Chen et al., 2022). This shift is particularly relevant to residential construction, where repetitive building components and extensive material choices create opportunities to improve economic efficiency without necessarily changing the fundamental functions of the dwelling. In an increasingly competitive housing market, the ability to identify unnecessary costs while preserving the intended performance of a building has consequently become an important engineering and managerial concern.

In practice, residential construction projects may experience cost inefficiencies arising from material selection, design decisions, construction methods, procurement conditions, and the use of specifications that exceed actual functional requirements. Such inefficiencies become more consequential when developers must maintain selling prices within market expectations while simultaneously responding to requirements for durability, safety, aesthetics, and occupant comfort. Value Engineering offers a structured approach to this problem by examining whether the required functions of a product, system, or building can be achieved at a lower cost without sacrificing reliability, quality, maintainability, or appearance (Miles, 1972). Its fundamental logic differs from conventional cost cutting because the objective is not simply to select the cheapest available material, but to maximize the relationship between function and cost through technically and economically justified alternatives (Zimmerman & Hart, 1998). The value-oriented perspective requires project components to be assessed according to the functions they perform and the resources required to deliver those functions. Value analysis in design similarly emphasizes the identification of unnecessary expenditure during the design and decision-making process, allowing alternative solutions to be considered before inefficient choices become embedded in project implementation (Fowler, 1990). This perspective makes Value Engineering particularly suitable for housing projects because architectural components often provide substantial opportunities for substitution while remaining subject to clearly defined functional and performance requirements.

Previous empirical research has demonstrated that Value Engineering can generate meaningful economic benefits across different types of construction projects, although the magnitude of savings is strongly influenced by project characteristics and the components selected for analysis. In the Green Semesta Housing Project in Semarang, the application of Value Engineering demonstrated the potential for optimizing residential construction expenditure through the assessment of alternative components while maintaining the intended requirements of the housing project (Faza et al., 2025). Similar evidence was reported in the Pesona Griya Asri Housing Project in Kudus, where redesign of type 36 and type 45 residential units was used to identify opportunities for reducing production costs through alternative design solutions (Noviyanti, 2022). Research on the Andalusia Housing Griya Giri Phase II Project in Gresik further confirms that residential developments contain cost-optimization opportunities that can be identified through systematic evaluation of construction components and alternative solutions (Muhammad et al., 2023). Comparable findings were obtained in the Mutiara Gading Housing Project in Bekasi, demonstrating that Value Engineering can be applied to residential development to identify alternatives capable of improving construction-cost efficiency (Susanto et al., 2023). The collective evidence suggests that residential projects are not merely passive recipients of cost-control measures but represent environments in which design standardization, repetitive work items, and material substitutability can support systematic value optimization. At the same time, the different savings achieved across these cases indicate that the effectiveness of Value Engineering cannot be reduced to a universal percentage of cost reduction because optimization potential depends on the specific design, construction technology, material market, and cost composition of each project.

Despite these developments, an important empirical and conceptual gap remains in the application of Value Engineering to architectural works within small- and medium-scale housing projects. Much of the existing literature has examined large infrastructure, institutional, or specialized building projects, while relatively fewer studies have focused specifically on the detailed optimization of residential architectural components such as walls, frames, floor finishes, roofs, and ceilings. Research on architectural works in the Citra Arafiq Serang Hospital project demonstrates that architectural components can provide significant opportunities for value optimization because alternative materials may achieve comparable functions with different cost implications (Maddeppungeng et al., 2024). Research on flats for educators at UGM Sleman also shows that systematic value engineering can identify alternative construction solutions, although the functional and technical characteristics of multi-unit flats differ from those of landed housing developments (Purwanty et al., 2023). Studies of bridge construction have similarly reported substantial savings through alternative structural and foundation solutions, but such findings cannot be directly transferred to residential architectural works because the functional hierarchy and technical constraints are fundamentally different (Iandryan, 2023). The literature therefore provides strong evidence for the general effectiveness of Value Engineering but remains less conclusive regarding how the method should be operationalized when the principal optimization opportunities are concentrated in repetitive architectural components of a housing project. This gap is important because a lower-cost alternative is only meaningful when it continues to satisfy the functional, technical, aesthetic, and durability requirements established for the housing product.

The unresolved issue has both scientific and practical significance because inappropriate material substitution may reduce initial expenditure while generating hidden costs associated with maintenance, replacement, reduced durability, or diminished user satisfaction. Contemporary value assessment research in traditional housing emphasizes that value should be evaluated through the relationship between functional requirements and the characteristics of design alternatives rather than through construction cost alone (Giménez et al., 2023). A similar concern is reflected in research integrating Building Information Modeling and Value Engineering, which argues that more systematic information and alternative evaluation can improve decision-making in residential construction and strengthen the connection between design information and value optimization (Gouda Mohamed et al., 2024). Research on bridge replacement projects has shown that substantial savings can be achieved through Value Engineering, including savings of up to 25% in foundation work, but the magnitude of savings is closely related to the specific alternatives and technical conditions of the project (Ainayyah & Rhomaita, 2022). Recent work on Value Engineering models for hospital buildings also reinforces the need to align cost optimization with applicable technical standards and building performance requirements rather than treating financial savings as the sole decision criterion (Riyanto et al., 2025). These findings establish the need for a project-specific investigation capable of distinguishing genuine value improvement from simple expenditure reduction. For the Mutiara Kedungmundu Housing Project in Semarang City, this issue is particularly relevant because optimization of architectural materials may directly influence the economic competitiveness of the development while simultaneously determining the visual, functional, and technical characteristics experienced by occupants.

Against this background, the present study is positioned within the residential construction value engineering literature by examining the Mutiara Kedungmundu Housing Project in Semarang City as a specific case of architectural cost and function optimization. The study retains the fundamental principle that value improvement should be achieved by identifying unnecessary costs and developing alternative solutions that continue to satisfy the required functions of the building components. The analysis focuses on identifying architectural work items with substantial optimization potential, generating feasible material alternatives, evaluating their functional and technical suitability, and determining the economic implications of the selected alternatives. This research is intended to address the limited project-specific evidence concerning how Value Engineering can be applied to repetitive architectural components in small- to medium-scale housing developments. The primary objective is to analyze the application of Value Engineering to the Mutiara Kedungmundu Housing Project, determine the architectural components that provide the greatest potential for optimization, identify the most appropriate alternative materials, and quantify the construction-cost savings resulting from the recommended alternatives. Theoretically, the study contributes to the value engineering literature by extending the discussion of function–cost optimization to a residential architectural context and by demonstrating how value-oriented decision-making can be applied to project-specific material choices. Methodologically, the study provides an integrated case-based framework for moving from information and functional identification to alternative evaluation and cost comparison, offering a practical analytical basis for more efficient, functionally appropriate, and economically rational decision-making in residential construction.

RESEARCH METHODS

The study employs an empirical, non-experimental case study design conducted at the Mutiara Kedungmundu Housing Project in Jl. Tlompak RT.07/RW.01, Sambiroto, Tembalang, Semarang City, with one type-50 housing unit selected as the research object and the analysis focused on architectural works. Primary data are obtained through field observation and interviews with the developer, while secondary data consist of the project Bill of Quantity (Rencana Anggaran Biaya/RAB), Analysis of Unit Prices (Analisis Harga Satuan Pekerjaan/AHSP), shop drawings, and material price data obtained from building-material suppliers and authorized distributors. The research follows the Value Engineering job plan, comprising the information, creative, analysis, and recommendation stages, in which the information stage includes cost breakdown, Pareto analysis, and functional analysis to identify high-cost architectural components and distinguish basic and secondary functions (Fowler, 1990). The relationship between cost and function is assessed using the Value Index based on the Cost/Worth approach, where Cost represents the total cost of an architectural work item and Worth represents the minimum cost required to achieve its basic function (Miles, 1972).

$$\text{Value Index (C/W)} = \text{Cost} / \text{Worth}$$

Architectural work items with C/W ≥ 1.5 are classified as having high potential for unnecessary costs and are subsequently prioritized for further analysis, while the creative stage develops technically feasible material alternatives based on market surveys and product information. The analysis stage then evaluates each alternative according to technical, functional, and economic criteria using a Zero-One paired-comparison matrix, while all work-volume calculations, AHSP and RAB preparation, Pareto analysis, alternative scoring, and cost comparisons are processed using Microsoft Excel to ensure a transparent and reproducible analytical procedure (Zimmerman & Hart, 1998).

The testing and validation procedure is performed through comparative technical and economic analysis of the original materials and the proposed alternatives rather than through laboratory experimentation, because the study evaluates project-specific material substitutions using documented construction data. Each alternative is first assessed for its ability to maintain the required function and technical characteristics of the original component, after which the Zero-One method assigns a score of "1" when an alternative is superior to its comparator and "0" when it is inferior, with the resulting total score determining the priority ranking. The alternative with the highest evaluation score is subsequently selected for detailed recalculation of the AHSP and RAB using equivalent work quantities, enabling the economic performance of the proposed solution to be compared directly with the original design. This evaluation approach maintains the fundamental principle of Value Engineering that cost optimization should improve the relationship between function and expenditure rather than simply reduce the initial project cost (Kartono, 2014). The principal quantitative performance metric is the percentage of cost saving calculated from the difference between the original and alternative costs, expressed as follows:

$$\text{Cost Saving (\%)} = [(\text{Initial Cost} - \text{Alternative Cost}) / \text{Initial Cost}] \times 100\%$$

The final validation is based on the consistency among functional adequacy, technical feasibility, Zero-One evaluation results, and measurable cost savings, while the recommended alternative is determined from its overall ability to provide the required function at a lower project cost, consistent with the application of Value Engineering in residential construction projects (Muhammad et al., 2023).

RESULTS AND DISCUSSION

Project Cost Structure and Information Analysis

The Mutiara Kedungmundu Housing Project comprises structural, architectural, mechanical-electrical-sanitation, and miscellaneous works with a total contract value of Rp241,879,138.69 for the type-50 housing unit examined in this study. The cost structure indicates that architectural works represent the largest expenditure component, amounting to Rp155,832,330.69, while structural works account for Rp75,865,408.00, mechanical-electrical-sanitation works Rp9,531,400.00, and other works Rp650,000.00. The relatively high proportion allocated to architectural works indicates that material selection within this work package can substantially influence the overall construction cost. This condition is particularly relevant in residential construction, where architectural components involve extensive material quantities and repeated applications across building elements. Value Engineering therefore requires the identification of cost-intensive components before alternatives are developed, because concentrating analytical effort on significant cost contributors provides greater potential for improving project value (Chen et al., 2022).

The architectural cost of Rp155,832,330.69 is distributed across seven major work groups, consisting of walls and door-window frames, floor and wall finishing, ceiling, roof, painting, accessory concrete, and miscellaneous works. The first four groups account for the majority of architectural expenditure, while painting, accessory concrete, and miscellaneous works contribute comparatively smaller proportions. This distribution demonstrates that the architectural budget is concentrated in several material-intensive components rather than being evenly distributed among all work groups. The cost breakdown consequently provides an initial quantitative basis for determining which components warrant detailed Value Engineering investigation. Such prioritization is consistent with the information phase of Value Engineering, in which project cost information is systematically organized to identify areas with significant opportunities for value improvement (Fowler, 1990).

.

Table 1. Breakdown Cost and Pareto Analysis of Architectural Works

Work Description	Price (Rp)	Weight (%)	Cumulative (%)
Walls, Door and Window Frames	53,057,500.39	34.05	34.05
Floor and Wall Finishing	36,978,257.99	23.73	57.78
Ceiling	21,484,693.44	13.79	71.56
Roof	17,946,424.60	11.52	83.08
Painting Works	14,348,364.27	9.21	92.29
Accessory Concrete	7,400,000.00	4.75	97.04
Others	4,617,090.00	2.96	100.00
Total	**155,832,330.69**	**100.00**	–

Source: Author's Analysis Based on the Project RAB

The second-highest contribution from floor and wall finishing increases the cumulative share of these two groups to 57.78%, while ceiling and roof works raise the cumulative proportion to 71.56% and 83.08%, respectively. The Pareto distribution therefore demonstrates a pronounced concentration of architectural expenditure in the first four work groups, providing a stronger analytical justification for prioritization than consideration based solely on individual material prices. The pattern is consistent with previous Value Engineering applications in residential projects, where architectural components frequently provide opportunities for material substitution and cost optimization without fundamentally altering the intended building function (Faza et al., 2025).

Based on the cumulative distribution in Table 1, the first four work groups reach 83.08% of the total architectural cost and are consequently selected as the principal areas for further Value Engineering analysis. The prioritized groups comprise walls and door-window frames, floor and wall finishing, ceiling, and roof works, with respective cost contributions of 34.05%, 23.73%, 13.79%, and 11.52%. Their combined value of Rp129,466,876.42 represents the dominant portion of the architectural budget and indicates that even moderate savings within these components can generate measurable project-level economic effects. The selection also prevents analytical resources from being dispersed across low-cost items whose potential savings would have a limited effect on the total architectural expenditure. A similar prioritization principle is evident in Value Engineering studies of architectural works, where high-cost work packages are subjected to subsequent functional analysis to identify potential unnecessary expenditure (Maddeppungeng et al., 2024).

The Pareto analysis, however, identifies cost concentration rather than directly establishing whether a particular expenditure is functionally justified. A high-cost work item may still represent an appropriate expenditure when its materials are necessary to achieve the required performance, durability, appearance, or constructability. The next analytical stage therefore requires functional assessment through the Cost/Worth relationship to distinguish legitimate costs from potential unnecessary costs within the prioritized work groups. This approach preserves the central Value Engineering principle that cost reduction should be evaluated in relation to the function delivered rather than treated as an independent objective (Zimmerman & Hart, 1998). The resulting prioritization provides a structured transition from project-level cost mapping to detailed functional analysis of the selected architectural components.

Functional Analysis and Identification of Value Improvement Opportunities

Functional analysis was conducted on the architectural work items identified through the cost breakdown and Pareto analysis to determine the relationship between expenditure and the functions delivered by each component. The assessment distinguishes the Basic Function (B), which represents the primary function that must be fulfilled, from Secondary Function (S), which supports the performance, appearance, or usability of the building component. Each function was formulated using a verb–noun structure to maintain a clear relationship between the required action and the object receiving that action. This functional decomposition is important because Value Engineering evaluates construction components according to the functions they provide rather than considering material cost as an isolated variable (Miles, 1972). The analysis subsequently compares the existing cost with the estimated Worth required to achieve the identified basic function.

The Cost/Worth assessment was applied to five architectural work items, namely walls, door and window frames, floor and wall finishing, roof, and ceiling works. These items were retained for functional analysis because they either represented substantial cost contributions or demonstrated characteristics that could provide opportunities for material optimization. The calculated Cost represents the expenditure associated with the existing solution, whereas Worth represents the estimated minimum expenditure required to provide the intended basic function at the required performance level. A C/W value close to 1.00 indicates that the existing expenditure is relatively proportional to the functional requirement, whereas a higher value indicates a greater difference between expenditure and functional worth. The interpretation of this relationship provides a quantitative screening mechanism for identifying components that warrant more detailed investigation in the creative stage (Kartono, 2014).

Table 2. Summary of Functional Analysis (Cost/Worth) by Work Item

Work Item	Basic Function	Cost (Rp)	Worth (Rp)	C/W
Walls	Enclose space	29,079,048.00	29,079,048.00	1.00
Door & Window Frames	Enclose/Form space	21,870,132.26	16,910,655.26	1.29
Floor & Wall Finishing	Cover walls/floors	36,978,257.99	28,202,927.04	1.25
Roof	Cover building	17,946,424.60	9,802,996.80	1.83
Ceiling	Cover ceiling	21,484,693.44	11,331,307.10	1.89

Source: Author's Analysis

The values in Table 2 indicate that roof and ceiling works exceed the C/W threshold of 1.50 established for prioritizing potential unnecessary costs. The roof records a C/W of 1.83, meaning that its existing cost is approximately 83% higher than the estimated Worth, while the ceiling records 1.89, indicating an approximately 89% difference between Cost and Worth. These values suggest that a considerable portion of expenditure may be associated with supporting components or material specifications that can potentially be optimized while maintaining the required building function. The finding is consistent with the functional orientation of Value Engineering, in which expenditure is examined against the level of function delivered rather than reduced indiscriminately (Fowler, 1990). The relatively high C/W values therefore provide a stronger indication of value-improvement potential than cost magnitude alone.

Although the wall work has a C/W value of only 1.00, it remains relevant for further analysis because it represents the largest cost contribution within the architectural work package. Its cost of Rp29,079,048.00 is fully equivalent to its estimated Worth, suggesting that the existing expenditure is functionally justified under the Cost/Worth assessment, but the high expenditure base means that material substitution may still generate economic benefits if the same basic function can be achieved at a lower cost. Door and window frames and floor and wall finishing present intermediate C/W values of 1.29 and 1.25, respectively, indicating less pronounced potential for unnecessary cost but still allowing investigation of technically equivalent alternatives. This distinction is important because Value Engineering should not restrict candidate selection exclusively to items exceeding a predetermined threshold when high-cost components may offer meaningful savings through alternative materials. Previous applications in residential construction similarly demonstrate that functional analysis can be combined with cost magnitude to identify material alternatives that improve project value (Muhammad et al., 2023).

The combined interpretation of cost contribution and functional value establishes five work items as candidates for the creative stage: walls, door and window frames, floor and wall finishing, roof, and ceiling. Roof and ceiling receive particular attention because their C/W values exceed 1.50, whereas walls are retained because of their substantial cost contribution and the potential economic effect of material substitution. This selection reflects a balanced decision framework in which both functional inefficiency and financial significance are considered before alternatives are generated. The approach is consistent with the broader development of Value Engineering practices in construction, where systematic identification of high-value improvement opportunities precedes the evaluation of alternative technical solutions (Ulkhaq et al., 2025). The selected items are subsequently examined through alternative material development and comparative technical-economic evaluation using the Zero-One method.

Creative Stage and Technical-Economic Evaluation of Material Alternatives

The creative stage was conducted by generating alternative materials for the five architectural work items selected from the functional analysis, with the alternatives required to maintain the basic function of the existing components. Material selection considered technical characteristics, functional suitability, installation requirements, durability, appearance, and relative economic feasibility based on market information available for the project. For wall works, the existing Citicon lightweight brick was compared with Blescon and Fastcon lightweight bricks, while the alternatives for door leaves consisted of Merbau wood with melamine finishing and Alexindo wood-grain aluminum. The alternatives were formulated to provide equivalent building functions while creating opportunities to reduce material and installation costs. This approach follows the creative principle of Value Engineering, which emphasizes the generation of multiple technically feasible solutions before determining the most appropriate alternative (Mendoca, 2015). The evaluation did not treat the lowest purchase price as the sole selection criterion because a cheaper material that fails to satisfy technical or functional requirements would not represent an improvement in value. The comparative evaluation therefore employed a Zero-One paired-comparison method to establish the relative performance of the alternatives across the selected criteria.

For wall works, the existing Citicon lightweight brick was evaluated against Blescon and Fastcon lightweight bricks using criteria representing their advantages and disadvantages. The advantages considered included light weight, dimensional precision, fire resistance, and ease of installation, while the disadvantages included requirements for specific adhesive materials and trained labor. Each alternative was compared according to these characteristics, with a score of 1 assigned when an alternative demonstrated superiority and 0 when it was inferior in the paired evaluation. The resulting scores were aggregated into an overall value that represented the relative position of each material within the decision matrix. The evaluation results presented in Table 3 show that Blescon achieved the highest final score of 2, compared with 1 for Citicon and 0 for Fastcon. The higher score indicates that Blescon provided the most favorable balance among the assessed technical characteristics within the alternatives considered. This result supports the selection of Blescon as the preferred wall material for subsequent cost recalculation and recommendation.

Table 3. Zero-One Weighting of Wall Material Alternatives

Material	Advantage Value	Disadvantage Value	Final Value
Existing Design: Citicon Lightweight Brick	2	1	1
Alternative 1: Blescon Lightweight Brick	3	1	2
Alternative 2: Fastcon Lightweight Brick	1	1	0

Source: Author's Analysis

The Zero-One assessment for the wall alternatives demonstrates that the Blescon material provides the strongest overall position when the advantages and disadvantages are evaluated comparatively rather than independently. Its final score of 2 results from an advantage value of 3 and a disadvantage value of 1, indicating that its technical benefits outweigh the limitations identified during the evaluation. The Citicon material, although representing the existing design, receives a lower final value of 1 because its assessed advantages do not provide the same comparative position as Blescon. Fastcon obtains a final value of 0, reflecting its comparatively weaker performance within the selected criteria. The result illustrates the importance of evaluating material alternatives through a structured decision procedure because a material with acceptable individual characteristics may still rank below another alternative when all criteria are considered simultaneously. Similar Value Engineering applications demonstrate that material substitution in architectural components can produce value improvements when technical adequacy and economic considerations are evaluated together (Maddeppungeng et al., 2024). The Blescon alternative was therefore carried forward to the subsequent economic assessment without assuming that its selection was based solely on material price.

A comparable evaluation was conducted for door leaves because this component forms part of the walls, door, and window frame cost group identified as the largest architectural expenditure category. The existing design uses teak wood door leaves, while the alternatives comprise Merbau wood with melamine finishing and Alexindo wood-grain aluminum. The evaluation considered material weight, resistance to termites and moisture, durability, appearance, and the ability to reproduce the visual characteristics expected from a residential door. The Zero-One comparison was applied using the same decision logic as the wall-material assessment so that each alternative was evaluated using a consistent scoring framework. As shown in Table 4, the Alexindo wood-grain aluminum alternative obtained the highest final score of 3, exceeding the Merbau alternative with a score of 1 and the existing teak door with a score of 0. The result indicates that the aluminum alternative provides the most favorable combined performance among the evaluated door-leaf materials. Its wood-grain finish also provides an appearance comparable to wood while offering resistance characteristics that are relevant to long-term residential use.

Table 4. Zero-One Weighting of Door Leaf Material Alternatives

Material	Advantage Value	Disadvantage Value	Final Value
Existing Design: Teak Wood Door Leaf	3	3	0
Alternative 1: Merbau Wood + Melamine Finishing	2	1	1
Alternative 2: Alexindo Wood-Grain Aluminum	4	1	3

Source: Author's Analysis

The results in Table 4 indicate that the Alexindo wood-grain aluminum door leaf has the strongest comparative performance because it achieves the highest advantage value while maintaining a relatively low disadvantage value. Its final score of 3 is primarily associated with characteristics such as lower weight, resistance to termites and moisture, and the ability of the wood-grain finish to maintain a residential wood-like appearance. The Merbau alternative obtains a final score of 1, suggesting that its characteristics remain technically acceptable but provide fewer comparative advantages within the defined evaluation framework. The existing teak door records a final value of 0 because its disadvantage score offsets the advantages considered in the paired assessment. The result is consistent with the broader Value Engineering concept that alternative selection should be based on the relationship between required function, technical performance, and resource expenditure rather than on material tradition or initial specification alone (Giménez et al., 2023). The selection of wood-grain aluminum also illustrates how contemporary material technologies can provide functional and aesthetic equivalence while creating opportunities for economic optimization. The same evaluation logic was extended to the remaining architectural components, including door and window frames, wall finishing, floor covering, roof, and ceiling materials, with the final alternatives subjected to cost recalculation in the recommendation stage.

Recommended Alternatives and Cost-Saving Performance

The recommendation stage determines the material alternatives that provide the most favorable balance between functional adequacy, technical feasibility, and construction cost based on the results of the Zero-One evaluation. The selected alternatives were subsequently incorporated into revised Analysis of Unit Prices (AHSP) and Bill of Quantity (RAB) calculations using the same work quantities as the existing design to ensure a comparable economic assessment. Seven material substitutions were identified across five architectural work items, covering walls, door leaves, door and window frames, wall finishing, floor covering, roof, and ceiling. The selected alternatives were not evaluated merely from their purchase prices, but from their ability to perform the required function while maintaining acceptable technical and aesthetic characteristics. This approach is consistent with Value Engineering applications in residential projects, where material substitution is used to improve the cost–function relationship while maintaining the required performance level (Susanto et al., 2023). The resulting material selections and their corresponding existing materials are presented in Table 5, providing the basis for calculating the savings associated with each recommended alternative. The comparison also demonstrates that Value Engineering can be implemented through targeted substitutions rather than comprehensive redesign of the housing unit.

Table 5. Selected Material Alternatives and Cost Savings

Work	Existing Material	Selected Alternative Material
Walls	Citicon Lightweight Brick 10 cm	Blescon Lightweight Brick 10 cm
Door Leaf	Teak Wood Door Leaf	Alexindo Wood-Grain Aluminum Door Leaf
Door & Window Frames	Kamper Wood Frames	Aluminum 4 (YKKAP)
Wall Finishing	MU-301 Main Mortar 40 kg	Multi Mortar
Floor Covering	Eleganza Granite Tile 60×60 cm	Garuda Granite Tile 60×60 cm
Roof	Corrugated Concrete Roof Tile	Flat Concrete Roof Tile
Ceiling	Kalsipart Ceiling 9 mm	Nusaboard Ceiling 9 mm

Source: Author's Analysis

The cost comparison indicates that the substitution of Kamper wood frames with Aluminum 4 (YKKAP) frames and teak wood door leaves with Alexindo wood-grain aluminum produces a combined saving of Rp1,138,363.04, equivalent to 17.01% of the existing cost of Rp7,830,485.26. The wall-finishing substitution from MU-301 Main Mortar 40 kg to Multi Mortar generates a saving of Rp2,475,600.00 or 18.51%, representing the highest percentage saving among the individual material substitutions. The floor-covering substitution from Eleganza 60×60 cm granite tiles to Garuda 60×60 cm granite tiles produces a saving of Rp782,145.00 or 6.77%, while the identical tile dimension maintains the intended floor-covering function. The roof substitution from corrugated concrete roof tiles to flat concrete roof tiles generates a saving of Rp1,023,660.00 or 11.66%, indicating that the roof component provides a meaningful opportunity for cost optimization without changing its fundamental weather-protection function. The ceiling substitution from 9-mm Kalsipart to 9-mm Nusaboard produces the smallest percentage saving of 2.53%, equivalent to Rp279,785.00, but remains economically relevant when considered as part of the cumulative savings from multiple architectural components. The range of savings demonstrates that the economic effect of Value Engineering varies substantially according to the cost structure and substitution potential of each component, which is consistent with findings from housing projects where different architectural elements generate different levels of cost efficiency (Noviyanti, 2022).

The revised costs were then aggregated at the architectural work-group level to determine the overall financial effect of the recommended alternatives. The calculation retained the original work quantities and modified only the material and associated unit-cost components affected by the selected alternatives, allowing the difference to be attributed directly to the Value Engineering intervention. The resulting comparison is important because savings at the individual material level do not necessarily correspond proportionally to savings at the total architectural-work level. Table 6 shows that the total architectural cost decreases from Rp155,832,330.69 to Rp144,998,247.48 after the recommended substitutions are incorporated. The resulting difference is Rp10,834,083.20, representing a total saving of 6.95% relative to the existing architectural cost. The largest absolute reduction occurs in walls, door and window frames at Rp6,253,557.84, followed by floor and wall finishing at Rp3,270,401.79. This distribution indicates that the magnitude of savings is strongly influenced by the initial cost base of each work group, rather than by percentage savings alone.

Table 6. Comparison of Architectural Work Costs Before and After VE

Work Description	Existing Cost (Rp)	Cost After VE (Rp)	Difference (Rp)
Walls, Door, Frames & Windows	53,057,500.39	46,803,942.54	6,253,557.84
Floor and Wall Finishing	36,978,257.99	33,707,856.20	3,270,401.79
Ceiling	21,484,693.44	21,198,229.87	286,463.57
Roof	17,946,424.60	16,922,764.60	1,023,660.00
Painting Works	14,348,364.27	14,348,364.27	–

.

Accessory Concrete	7,400,000.00	7,400,000.00	–
Others	4,617,090.00	4,617,090.00	–
Total	**155,832,330.69**	**144,998,247.48**	**10,834,083.20**

Source: Author's Analysis

The distribution in Table 6 indicates that the walls, door, frames, and windows group contributes approximately 57.7% of the total architectural cost saving, while floor and wall finishing contributes approximately 30.2%. These two work groups therefore account for the majority of the economic benefit generated by the recommended alternatives, whereas the ceiling and roof contribute smaller absolute amounts despite the relatively high C/W value identified during functional analysis. The difference illustrates that a high Cost/Worth ratio should not be interpreted as an automatic indicator of the largest monetary saving, because the final saving also depends on the volume of work, existing material price, and cost structure of the selected alternative. This finding reinforces the importance of combining functional analysis with detailed economic recalculation during Value Engineering rather than relying on a single screening indicator. Comparable residential Value Engineering research has shown that systematic material evaluation can generate measurable savings while preserving the intended function of housing components (Faza et al., 2025). The present results further indicate that the most economically influential substitutions occur in work packages with both substantial initial expenditure and feasible material alternatives. Such an outcome supports the use of an integrated technical-economic evaluation when determining final recommendations for residential construction.

The recommended alternatives collectively reduce the architectural budget by 6.95%, demonstrating a measurable improvement in cost efficiency while retaining the functional requirements established during the functional and technical evaluations. The result is lower than the 7.75% architectural saving reported by Yaqin and Priasworo (2023) for the Rumah Sakit Keluarga Sehat III Semarang project, but the difference can be interpreted in relation to the distinct scale, building function, and range of architectural components available for optimization. The present study focuses on a single type-50 housing unit, where the scope of material substitution is narrower and the economic base of each work item is relatively smaller than that of a hospital building. Research on housing projects has similarly demonstrated that Value Engineering can improve economic efficiency through selective material substitution without requiring fundamental changes to the building concept (Muhammad et al., 2023). The 6.95% saving therefore represents a meaningful result within the defined scope because it is achieved through targeted modifications to architectural materials rather than reductions in required quantities or functional standards. The recommendations also provide the developer with a practical basis for material procurement decisions, particularly for components whose initial costs constitute a significant proportion of the architectural budget. The findings support the application of Value Engineering as a structured cost-optimization approach in residential construction, while the technical acceptability of each substitution remains essential to prevent economic savings from compromising building performance.

CONCLUSION

Based on the Value Engineering analysis of the architectural works of the Mutiara Kedungmundu Housing Project in Semarang City, five work items were identified as having optimization potential, namely walls, door and window frames, floor and wall finishing, roof, and ceiling. The Zero-One analysis resulted in seven selected material alternatives, consisting of 10 cm Blescon lightweight brick, Alexindo wood-grain aluminum door leaves, YKKAP aluminum frames, Multi Mortar, 60×60 cm Garuda granite tiles, flat concrete roof tiles, and 9 mm Nusaboard ceiling. The selected alternatives were determined based on their ability to maintain the required building functions, quality, and aesthetic performance. The architectural work cost decreased from Rp155,832,330.69 to Rp144,998,247.48 after the application of Value Engineering. This reduction generated a total cost saving of Rp10,834,083.20, equivalent to 6.95% of the initial architectural cost. The result indicates that Value Engineering can improve cost efficiency in residential construction through systematic function analysis and appropriate material selection. The findings also demonstrate that material substitution can provide measurable economic benefits while maintaining the primary functions and required performance of the building.

The 6.95% saving reflects the potential of Value Engineering to optimize architectural construction costs within the scale and scope of the analyzed housing project. The magnitude of the saving is influenced by the project scale, existing material specifications, and the range of architectural elements included in the evaluation. Value Engineering is recommended to be implemented during the design stage so that alternative materials and design solutions can be assessed before construction decisions become fixed. Material selection should consider not only initial cost but also quality, service life, constructability, local material availability, and long-term maintenance requirements. Future research should use updated material price data, expand the analysis to structural elements while maintaining safety requirements, compare a wider range of material alternatives, and incorporate project technical specifications such as the Work Plan and Requirements (RKS). These additional considerations can improve the accuracy and comprehensiveness of the Value Engineering evaluation. The approach can also support more effective decision-making for achieving cost efficiency while maintaining functional, technical, and aesthetic requirements in future residential construction projects.

REFERENCES

Ainayyah, R. A., & Rhomaita, R. (2022). *Penerapan Value Engineering Pada Proyek Jembatan (Studi Kasus: Proyek Pembangunan Jembatan Progo–Kranggan, CS)* (Doctoral dissertation, Universitas Islam Sultan Agung). https://repository.unissula.ac.id/25736/

Chen, W. T., Merrett, H. C., Liu, S. S., Fauzia, N., & Liem, F. N. (2022). A decade of value engineering in construction projects. *Advances in Civil Engineering*, *2022*(1), 2324277. https://doi.org/10.1155/2022/2324277

Dimyati, H., & Nurjaman, K. (2014). *Manajemen Proyek*. Pustaka Setia.

Faza, M. A., Antonius, A., & Wibowo, K. (2025). Value engineering analysis of the green semesta housing project in Semarang. *International Journal of Mechanical Computational and Manufacturing Research*, *13*(4), 105-112. https://doi.org/10.35335/computational.v13i4.226

Fowler, T.C. (1990). *Value Analysis in Design*. Van Nostrand Reinhold.

Giménez, Z., Mourgues, C., Alarcón, L. F., Mesa, H., & Pellicer, E. (2023). Value assessment in the traditional housing design: Case studies applying a value analysis model. *Ain Shams Engineering Journal*, *14*(9), 102089. https://doi.org/10.1016/j.asej.2022.102089

Gouda Mohamed, A., Alqahtani, F. K., Ismail, E. R., & Nabawy, M. (2024). Synergizing BIM and value engineering in the construction of residential projects: a novel integration framework. *Buildings*, *14*(8), 2515. https://doi.org/10.3390/buildings14082515

Iandryan, A. (2023). *Analisa Value Engineering pada Pembangunan Jembatan Sungai Gondang Proyek Jalan Tol Solo–Ngawi STA 49+ 553* (Doctoral dissertation, Universitas Islam Sultan Agung Semarang). https://repository.unissula.ac.id/28588/

Kartono. (2014). *Value Engineering dalam Proyek Konstruksi*. Graha Ilmu.

Maddeppungeng, A., Asyiah, S., Intari, D. E., Setiawati, D. N., Damanik, M. F., & Rizky, E. M. (2024). Value Engineering Analysis of Architectural Works in Construction Projects (Case Study of Citra Arafiq Serang Hospital Development). *Fondasi: Jurnal Teknik Sipil*, *13*(2), 298-309. https://dx.doi.org/10.62870/fondasi.v13i2.32724

Mendoca, A. (2015). *Value Engineering and Functional Analysis in Construction Projects*. McGraw-Hill Education.

Miles, L.D. (1972). *Techniques of Value Analysis and Engineering*. McGraw-Hill.

Muhammad, M., Witjaksana, B., & Tjendani, H. T. (2023). Value Engineering Analysis On Andalusia Housing Proy Griya Giri Phase II In Gresik District. *Devotion: Journal of Research and Community Service*, *4*(2), 361-373. https://doi.org/10.36418/dev.v4i2.390

Noviyanti, E. (2022). Analisis value engineering pada proyek Perumahan Pesona Griya Asri di Kabupaten Kudus. *Menara: Jurnal Teknik Sipil,* *17*(1). https://doi.org/10.21009/jmenara.v17i1.25141

Purwanty, K. I., Oetomo, W., & Nugroho, L. D. (2023). Analyst Is Value Engineering On The Construction of Flats For Educators UGM Sleman. *Devotion: Journal of Research and Community Service*, *4*(2), 347-360. https://doi.org/10.36418/dev.v4i2.389

Riyanto, J., Wahyudi, S. I., & Wibowo, K. (2025). Value Engineering Model of Hospital Buildings According to Building Technical Standards in Indonesia. *ASTONJADRO*, *14*(4), 1151-1162. https://doi.org/10.32832/astonjadro.v14i4.19097

Soeharto, I. (1995). *Manajemen Proyek: Dari Konseptual Sampai Operasional*. Erlangga.

Susanto, R. A., Paryati, N., & Nuryati, S. (2023). Value Engineering in Mutiara Gading Bekasi City Housing Project. *SITEKIN: Jurnal Sains, Teknologi dan Industri*, *20*(2), 691-698. https://doi.org/10.24014/sitekin.v20i2.21912

Ulkhaq, M. M., Pramono, S. N., Hapsari, C. A. P., & Ahmad, S. R. (2025). Value engineering practices in Indonesia: A systematic literature review. *Architecture Image Studies*, *6*(3), 1368-1381. https://doi.org/10.62754/ais.v6i3.460

Yaqin, B. A., & Priasworo, B. S. (2023). *Value Engineering pada Proyek Pembangunan Gedung Rumah Sakit Keluarga Sehat III Semarang* (Doctoral dissertation, Universitas Islam Sultan Agung Semarang). https://repository.unissula.ac.id/32685/

Zimmerman, L.W., & Hart, G.D. (1998). *Value Engineering: A Practical Approach for Owners, Designers, and Contractors*. CBS Publishers.