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Application Of Value Engineering in a Three-Storey Building Construction Project

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Value Engineering, Cost Savings, Commercial Buildings

ABSTRACT
The Three-Story Building Construction Project functions as a souvenir shop with a project value per m^2 of Rp 9,962,985. Research conducted by Atmaja (2023) on the construction project of the Bali Land Transportation Education and Training Center Administration Building was carried out for cost efficiency because the project cost per m^2 was 4,143,968. Therefore, a review was conducted using the Value Engineering (VE) method to reduce costs without reducing the function of the building. The purpose of this study was to analyze structural and architectural work items with value engineering and analyze the amount of cost savings. VE consists of 6 stages: the information stage, the function analysis stage, the creative stage, the evaluation stage, the development stage, and the recommendation stage. The information stage was carried out by collecting information about the project, followed by a Pareto diagram which was used to find 20% of work items that produced 80% of the total project cost, then those items were analyzed. The function analysis stage was carried out using the FAST Diagram (Function Analysis System Technique) to determine the main function of each item. Furthermore, the creative stage produced several alternative designs as a replacement for the initial design. In the evaluation stage, SAP2000 was used for structural analysis and Analytical Hierarchy Process (AHP) was used to determine the best alternative. The development stage was conducted with technical analysis and Life Cycle Cost (LCC) calculations. Furthermore, in the recommendation stage, the results of the VE analysis of the evaluated alternatives were reported. The results of the VE analysis showed that savings could be made on structural work by replacing the initial design of composite beams and columns with conventional beams and columns, and on architectural work by replacing red bricks with lightweight bricks. Thus, the percentage of savings on structural work costs was 37.1% and walls 3.516% of the initial RAB.

DOI:

INTRODUCTION

Development project construction in Bali very much develop rapidly. Method construction has role important in success A project Because related direct by achieving three main targets, namely cost, quality, and time. This Three-Story Building Construction Project It functions as a commercial building with a building area of 2,576 m^2. The project uses a profile steel structure and K-300 concrete quality. The building construction project planned to be completed on September 6, 2026. Currently the project is in the planning stage with a RAB value of Rp 25,664,649,000, so it can be seen that the project cost per m^2 is Rp 9,962,985. In the research conducted by Atmaja (2023)the Bali Land Transportation Education and Training Center Administration Building construction project, cost efficiency was carried out because it had a total project cost of Rp 19,107,838,876 with a building area of 4,611 m^2. So, on study this done review return with use method which study repeat design to implementation in field, reducing costs without compromising functionality. The method that can be used is value engineering (VE). Value engineering analysis method has advantages, namely the existence of a systematic, neat, and planned approach in analyzing the value of the main problem regarding its function or use but remains consistent with the appearance, quality, and maintenance of the project Diputera et al. (2018). According to Dell'Isola (2008)there are three basic elements needed to measure a value, namely function, quality, and cost. Value Engineering (VE) is a decision-making process that involves a team from various disciplines, which is carried out in a systematic and organized manner, to achieve optimal value in a project, while maintaining the required quality, function, and performance. Value engineering can also improve decision-making that leads to cost optimization. Value engineering (VE) is a creative and systematic approach with the aim of reducing or eliminating unnecessary costs Zimmerman & Hart (1982). Value engineering is used to obtain an alternative or idea that aims to obtain a better or lower cost than the initial planning cost without ignoring the quality of the work. This is a project management concept that focuses on cost control to find ways to be more efficient such as determining the most efficient price for goods/services systematically without changing the function of the building/work Abdi et al. (2017). The goal of the value engineering concept is to identify opportunities to eliminate unnecessary costs while ensuring the quality and function of the building Ilayaraja & Zafar Eqyaabal (2015). The steps in implementing value engineering are as follows: engineering consists of from six stages, that is : stage information (information phase), function analysis stage, creative stage (creative phase), evaluation stage (evaluation phase), development stage (development phase) and recommendation stage (recommendation phase).

Value engineering analysis at the information stage involves collecting information regarding project, to be continued with diagram Pareto Which used for find the 20% of work items that account for 80% of the total project cost will then be analyzed. The functional analysis stage is then continued. The method used to analyze functions is the FAST diagram (Function Analysis System Technique) to make it easier. get function main from items work Which reviewed. To be continued with creative stage for bring up design alternative Which Can minimize cost project. The selected design will be analyzed in the evaluation stage to obtain the best results. At that stage, using the SAP 2000 program to analyze the structure of the alternative structural work so that it can withstand the planned load. Then, using the Analytical Hierarchy Process (AHP) method, the method is used to select or select design alternatives to obtain the best alternative Bahri & Indryani (2018). According to Saaty (1990), hierarchy is defined as a rerecommendation of a complex problem in a multi-level structure starting from objectives, criteria, sub-criteria, and alternatives at successive levels. Then, in the development stage, using technical analysis and Life Cycle Cost (LCC) calculations on work that has been analyzed in detail through value engineering. Furthermore, at the recommendation stage, the results of the value engineering analysis of the evaluated alternatives are reported.

Objective in study This For determine items work Which potential analyzed with value engineering, know criteria Which worthy used as alternative design and to determine the cost savings obtained by applying Value Engineering. Furthermore, VE can be applied to similar projects to obtain more economical design alternatives without compromising the quality and function of the building.

VALUE ENGINEERING CONCEPT

Value Engineering (VE) is an approach that aims to achieve the best value in a project or process by defining the functions required to achieve those goals, and providing those functions at the most efficient cost, without sacrificing quality or desired performance. According to Kelly et al. (2014)the main concept of the VE methodology lies in the value with the relationship between function and cost. According to the SAVE (2007)Value Engineering (VE) methodology which is structured and follows a work plan (job plan) divided into three stages, namely the pre-workshop stage, the workshop stage, and the post-workshop stage.

1. Workshop stage
   This stage aims to plan and prepare the VE study, as well as preparation for the next study stage.
2. Workshop stage
   At this stage there is a work plan which is arranged sequentially. The steps carried out at this stage can be explained as follows:
   a) Information Stage: In the information stage, various data are collected regarding the project that will be the object of study. The data collected includes: planning drawings, budget plans, and the work methods to be used. After obtaining sufficient information, issue identification is carried out, followed by a comparative analysis using a Pareto Diagram to rank the work items that determine the scope of the VE work, namely work with a cost of cumulative 80% of the total cost
   b) Stage Analysis Function: On stage analysis function there is a number of activities Which carried out, namely function identification, function classification, and development of function models. In compiling model function, used diagram FAST. A FAST diagram is a diagram of the subsystem functions of a component that shows the specific relationships between all functions and clearly shows what the subsystem does. Yana et al. (2019). This diagram helps answer the questions 'how' and 'why' in a clear way. systematic, building hierarchy functional Which clear from function level tall until function causative.
   c) Stage Creative: On stage creative, various alternative proposed as A comparison of previously created designs, in accordance with the limitations of the functional analysis phase. The more alternative ideas, the more solutions can be offered to save costs, increase functional efficiency, maintain quality, and reduce implementation time, thereby achieving construction project efficiency. In this phase, alternative ideas come from literature studies, brainstorming, and field reviews, and include new innovations that are superior in technology or in work methods, as well as eliminating deficiencies in the initial plan.
   d) Stage Evaluation: Election alternative Which in accordance from a number of alternative Which has arranged on stage creative. For work structure, SAP2000 is used for comprehensive structural analysis to verify that alternative designs meet structural safety requirements as planned. The Analytical Hierarchy Process (AHP) method is used to determine the best alternative design based on indicators including cost, quality, time, and aesthetics.
   e) Development Phase: Further analysis of the selected alternatives is carried out through a combination to find the best option with the lowest cost. The LCC calculation includes initial costs (construction phase costs) and maintenance costs (periodic maintenance and repair costs, including component replacement if seriously damaged). This consider age building 40 years for element structure, Then the maintenance costs of architectural work are calculated using LCC.
   f) Recommendation Stage: A report of the analysis results is prepared, including data on the selected alternatives, the cost difference between the initial plan and the total cost after VE. This recommendation aims to provide stakeholders with sufficient information to make informed decisions regarding the use of alternatives.
3. Post-workshop stage
   At this stage, follow-up is carried out on the recommendations approved in the previous workshop. All approved alternatives are prepared for implementation during the construction phase and are continuously monitored in accordance with the VE study

phase to ensure the objectives and benefits of implementing these alternatives are maximized.

METHOD

The method used is the method descriptive quantitative, where study this describes the subject or object being studied through numerical data analysis. Each stage is a crucial part that determines the continuation to the next stage. In this study used method value engineering for study repeat design to implementation in the field, with reduce cost without reduce Function. The stages analyzed in the VE method are the information stage, the function analysis stage, the creative stage, the evaluation stage, the development stage, and the recommendation stage. In the information stage, information about the project is collected, followed by a Pareto diagram used to find the 20% of work items that produce 80% of the total project costs, then those items will be analyzed. Then, the function analysis stage continues, the method used to analyze the function is the FAST diagram (Function Analysis System Technique) to more easily obtain the main function of the work items being reviewed. Continued with the creative stage to come up with alternatif a design that can minimize project costs. The selected design will be analyzed in the evaluation stage to obtain the best results used for further analysis. At this stage, the SAP 2000 program is used to analyze the selected structure in the alternative structural work so that it can withstand the planned load. Next, the Analytical Hierarchy Process (AHP) method is used to select or select the alternative designs used. The assignment of these values is carried out using a questionnaire. To reach a consensus in its assessment, the average of the respondents' assessments is taken because the " reciprocity " characteristic of the matrix used in the AHP analysis must be maintained. Then, in the development stage, using technical analysis and Immawan & Pratama (2016). Life Cycle Cost (LCC) calculations to obtain cost savings on the types of work that have been analyzed in detail by value engineering. Next, in the recommendation stage, the results of the value engineering analysis of the alternatives that have been evaluated are reported.

RESULTS AND DISCUSSION

Value engineering is a method used to achieve optimal value in a project while maintaining quality and functionality. Value engineering consists of six stages: information, function analysis, creative, evaluation, development, and recommendation.

1. Information Stage

At the information stage, data collection included building planning drawings and the Cost Budget Plan (RAB). The project functions as a commercial building with a total building area of 2,576 m². The building has a total project value of Rp25,664,649,000. After obtaining sufficient information, issue identification was carried out using the Pareto method. This study used a Pareto diagram because the diagram presents data with cumulative bar and line graphs, making it easier to see significant costs. In this study, no VE analysis was conducted on MEP work, this is because every component his job own role important in performance system in a way the whole building as well as specification determined by the owner accordingly with needs. At work floor, no done VE analysis due to granite type determined by the owner.

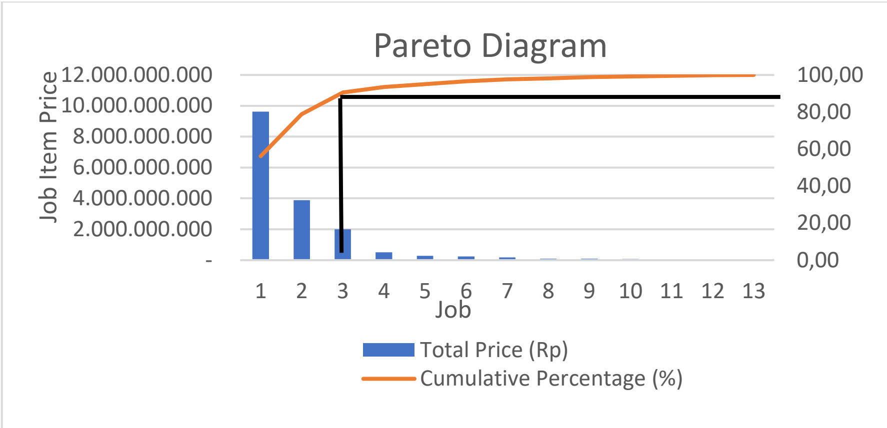

Figure 1 Pareto Diagram

Figure 1 shows that the numbers 1 to 13 on the X-axis (horizontal) represent the work items listed in Figure 1, while the Y-axis (vertical) shows the value or price of each work item. The blue bar chart depicts the total cost for each work item, while the orange line chart shows the cumulative percentage of the total work cost. The black line marks the limit of the work items that, when added together, provide the highest accumulated cost. There are 3 types of work items with the highest costs that VE can carry out, namely:

1. Structural Work
2. Foundation Work
3. Wall Work

1. Function Analysis Stage

After gathering project information, the next step is to conduct a functional analysis. The functional analysis phase involves several activities, including function identification, function classification, and functional model development using a FAST Diagram.

Analysis of Work Function Structure: In the figure it can be explained that the scope of the problem from left to right is a function from high level to low level functions which are connected by a critical path.

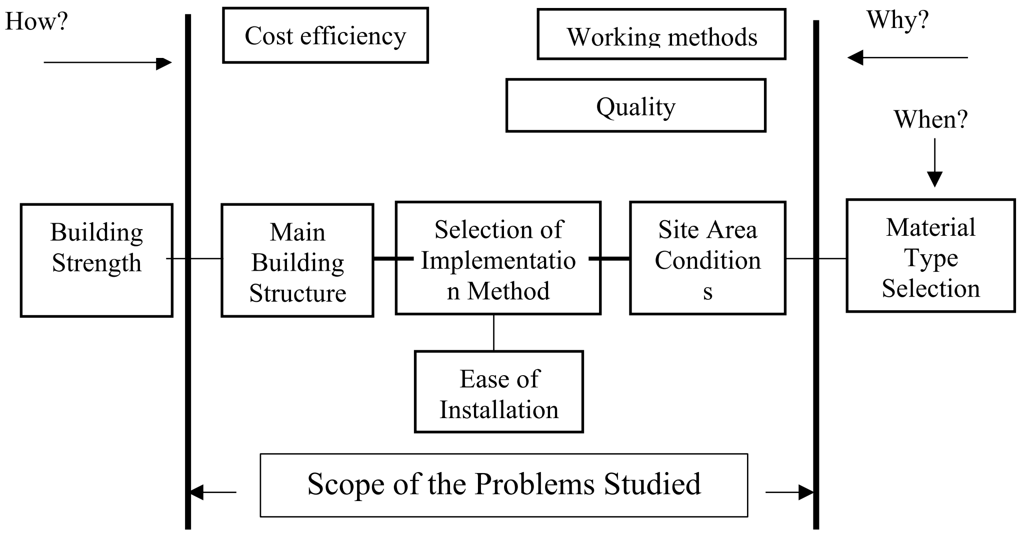

Figure 2 FAST Diagram Stucture

The basic function of structural work is as the main structure of the building. The basic function answers the question of how the higher-level function (functions outside the scope of the left line) and conversely, the higher-level function answers the basic function.

- Question how: How to "Ensure the Strength of the Building" to be in accordance with the plan? Response: by having a "Main Building Structure." And, conversely, Question why

“Why is a “Main Building Structure” necessary?” Response: to “Ensure the Strength of the Building.”

Furthermore, there is a secondary function that is connected to the critical path, namely "Selecting the appropriate Implementation Method" because this is related to the function of ease of installation at the project location and control of waste materials.

- Question: How to get the “Main Building Structure” according to the planned quality? Response: with the right “Choice of Implementation Method” related to ease of installation, and vice versa why is it necessary to implement the “Choice of the right Implementation Method”? Response: to get the “Main Building Structure” according to the planned quality.
- Question how: How to get the right “Implementation Method”? Response: by conducting a “Conditions in the Site Area” survey, and conversely why is it necessary to conduct a “Site Conditions” survey? Response: for the right “Implementation Method Selection”.

  Then there is a low-level function that is outside the scope (on the right), namely Material Type Selection.
- Question when: When is the “Material Type Selection” carried out? Response: after conducting a survey of the “Site Conditions” in order to obtain the appropriate implementation method in the construction of the Main Structure of the Building according to the plan so that the Building Strength will be guaranteed. The question of how for the secondary function (Implementation Method Selection) is also answered by the causative function, and conversely the question of why the causative function will be answered by the secondary function.

  The objective functions are cost efficiency, work methods and quality which will later be used as a reference in the next stage (Creative Stage).

Foundation Work Function Analysis: The FAST diagram for foundation work defines 'Ensuring Building Structural Strength' as a high-level function. Its basic function is 'Building Substructure', the selection of the right foundation is adjusted to the weight of the building load and conditions in the site area. After conducting a survey of the site conditions and knowing the building load in order to get the right type of foundation selection in the construction of the Building Substructure according to the plan so that the Building Strength will be guaranteed. The objective functions for foundation work include cost efficiency, material quality and work methods which will later serve as a reference in the next stage (Creative Stage).

2. Creative Stage

At this stage, several alternative designs will be proposed to compare previously developed designs, consistent with the limitations of the functional analysis. At this stage, alternative ideas are derived from literature studies, brainstorming, and field reviews. They include new innovations that are superior in technology or work methods, as well as eliminating deficiencies in the initial plan, making them suitable alternatives.

a. Structural Work: based on the results of discussions or brainstorming, 4 alternatives were obtained, namely: conventional column and beam method, precast column and beam method, conventional plate method, precast plate method. In this study, the alternatives chosen were the conventional column and beam alternative and the conventional plate method as a replacement for composite beam and column work and metal deck plates, because these alternatives fulfill all functions according to the scope determined at the function analysis stage. The precast column, beam, and plate alternatives were not selected due to the dense site conditions due to shop activities that remain operational. In addition, the project area is narrow so that access and installation of precast beam, column, and plate materials are very difficult.
b. Foundation Work: Based on the results of discussions or brainstorming, two alternatives were obtained, namely: the pile foundation method and the well foundation (cycloop). The pile foundation alternative was not selected in this study because the implementation method

has the potential to cause negative impacts on the surrounding environment. The piling process produces noise that can disturb surrounding activities. This consideration is important considering that the project location is in a sensitive area, namely a shop that is still operational and an elementary school that is still actively carrying out teaching and learning activities.

The well foundation (cycloop) alternative was not selected in this study, because the soil structure in the project area is clay soil, so it requires a foundation that can reach hard soil at a certain depth.

In this study, borepile and pilecap foundations were still chosen as the substructure because the implementation method was considered most appropriate to the environmental conditions at the project location.

c. Wall Work: Based on the results of the discussion or brainstorming, 3 alternatives were obtained, namely: lightweight brick walls, concrete block walls, and partition walls. In this study, alternatives 1 and 2, namely lightweight brick walls and concrete block walls, were chosen as replacements for red brick walls because they fulfill the function according to the scope of the previous stage (function analysis stage). Alternative 3, namely partition walls, was not selected in the study because the walls are not resistant to water, wind, and heat.

3. Evaluation Stage

At this stage, the best alternative will be selected in terms of cost, quality, time, and aesthetics using the AHP method, ensuring the chosen idea is feasible for use. For structural work in this phase, the alternatives used will first be analyzed using the SAP 2000 application.

a. Structural Work: All structural alternatives were analyzed using SAP2000. This building is located in Tabanan, Bali, with seismic parameters Ss (Spectral Acceleration Short Period) = 0.9827g and S1 (Spectral Acceleration 1 Second Period) = 0.3983g, classified as Seismic Design Category D which requires a Special Moment Resisting Frame (SRPMK) system. The soil classification is SE (soft soil), so it requires an appropriate footing coefficient in the seismic calculation. The planned concrete quality is 25 Mpa, with additional dead load of floors 1, 2, 3, and 4 = 600 kg/m. The planned live load for floor 1 = 488.346 kg/m ^{2} and for above floor 1 = 366.07 kg/m ^{2} .

Alternative A1 (composite columns and beams with metal deck plates), this alternative uses the initial design according to the planning.

Alternative A2 (conventional columns and beams with metal deck plates) uses column dimensions of 900x900 mm for floors 1-3, main beams of 700x600 mm, and sub-beams of 600x500 mm. Modal analysis yields mass participation ratios of 95% (X direction) and 94% (Y direction), with a dynamic to static base shear ratio exceeding one. Reinforcement requirements increase proportionally: columns with 28D19 bars and D10-100 mm stirrups, main beams with 6D19 top bars and 5D19 bottom bars. Alternative A3 (composite with conventional slabs) shows mass participation ratios of 92% (X direction) and 91% (Y direction), slightly above the 90% threshold, with satisfactory base shear ratios and drift limits.

Alternative A3 (composite columns and beams with conventional slabs) uses the beam and column dimensions as originally planned, replacing the metal deck with conventional slabs. The analysis data for this alternative is the same as for Alternative 2.

AHP Analysis Results: The AHP methodology systematically evaluates alternatives based on four indicators: cost, quality, time, and aesthetics. The assessment assigns indicator weights through a pairwise comparison matrix. For structural work, the highest weight is quality (0.57), which reflects the project priority, followed by cost (0.28), aesthetics (0.12), and time (0.03). A consistency ratio of 0.058 (below the threshold of 0.10) confirms the consistency of the assessment.

These alternatives were assessed based on each indicator using a score of 1 to 3. Alternative A2 achieved the highest score, 2.77. Alternative A3 achieved a score of 2.16. Alternative A1 achieved the lowest score, 2.13.

b. Foundation work: in foundation work, bore pile foundations are still used because these foundations are suitable for field conditions.
c. Wall work: Based on the previous stage (creative stage), for the wall work, 2 alternatives were chosen, namely the brick wall alternative and the lightweight brick wall alternative as a replacement for the red brick wall work.

Alternative C1 (red brick): a building wall made of red brick bonded together using mortar (a mixture of cement, sand, and water). Red brick walls have the advantage of being fire and heat resistant and have good sound absorption.

Alternative C2 (brick): Brick walls are made from a molded and dried mixture of cement, sand, and water. Brick walls can be used for both structural and non-structural purposes. Brick has a smoother surface, saving on plaster.

Alternative C3 (lightweight brick): Lightweight brick is currently a popular material due to its light and strong properties. Lightweight brick is generally made from a mixture of materials such as silica sand, cement, lime, gypsum, water, and a developer that forms air bubbles within the structure.

For wall work, the indicator weights prioritize aesthetics (0.42), cost (0.31), quality (0.18), and time (0.09). A consistency ratio of 0.094 (below the 0.10 threshold) confirms the consistency of the assessment.

These alternatives were assessed based on each indicator using a score of 1 to 3. Alternative C3 achieved the highest score, 2.47. Alternative C1 achieved a score of 2.06. Alternative C2 achieved the lowest score, 1.69.

Table 1Results of Structural Work Evaluation

Alternative	**Total cost**	**AHP Weight**	**Ranking**
Composite Columns and Beams and Metal Deck Plates (A1)	Rp. 9,116,253,688	2.13	3
Conventional Columns and Beams and Metal Deck Plates (A2)	Rp. 6,046,462,020	2.77	1
Composite Columns and Beams and Conventional Plates (A3)	Rp. 9,007,939,423	2.16	2

4. Development Stage

At this stage, further analysis will be carried out on the selected alternatives by combining the selected alternatives to obtain the best alternative with the lowest cost, thus producing a complete proposal using the Life Cycle Cost (LCC) method. In this work structure concrete, steel structures and foundations No take into account cost maintenance costs because considered the same with age 40 years old building.

From these alternatives, 9 alternative design options were obtained as recommended options. Selection is made randomly by combining alternative structural, foundation, and wall designs one by one. The total cost of each alternatif design combination can be seen in Figure Table 2.

Table 2Selection of Alternative Design Combinations

No.	Combinations			Total Price	Ranking
	Structural Work	**Foundation Work**	**Wall Work**		
1	Composite Columns and Beams and Metal Deck Plates (A1)	Bore pile foundation (B1)	Red Brick Wall (C1)	17,632,558,820	9
2	Composite Columns and Beams and Metal Deck Plates (A1)	Bore pile foundation (B1)	Concrete block wall (C2)	17,409,289,540	6
3	Composite Columns and Beams and Metal Deck Plates (A1)	Bore pile foundation (B1)	Lightweight brick walls (C3)	17,441,593,044	7
4	Conventional Columns and Beams, Metal Deck Plate (A2)	Bore pile foundation (B1)	Red Brick Wall (C1)	14,562,767,152	3
5	Conventional Columns and Beams, Metal Deck Plate (A2)	Bore pile foundation (B1)	Concrete block wall (C2)	14,339,497,872	1
6	Conventional Columns and Beams, Metal Deck Plate (A2)	Bore pile foundation (B1)	Lightweight brick walls (C3)	14,371,801,376	2
7	Composite Columns and Beams and Conventional Plates (A3)	Bore pile foundation (B1)	Red Brick Wall (C1)	17,524,244,554	8
8	Composite Columns and Beams and Conventional Plates (A3)	Bore pile foundation (B1)	Concrete block wall (C2)	17,300,975,275	4
9	Composite Columns and Beams and Conventional Plates (A3)	Bore pile foundation (B1)	Lightweight brick walls (C3)	17,333,278,779	5

Based on the evaluation of all alternative design combinations, the lowest-cost combination was the fifth option, as shown in Table 2: conventional column and beam construction, borepile foundations, and lightweight brick walls. Because brick walls are more porous (water-absorbing), lightweight brick walls were used in this study because they are relatively watertight and more moisture-resistant, making them suitable for humid areas. Therefore, the sixth potential alternative is:

1. Conventional Column and Beams
2. Borepile foundations
3. Lightweight brick walls

5. Recommendation Stage

Several comparative indicators were used in selecting design alternatives, covering aspects of cost, quality, time, and aesthetics based on the object being reviewed. The design alternatives selected for structural work included conventional columns and beams with metal deck plates. The foundation work retained the initial design, namely a borepile foundation, as this method was most suitable for the project's conditions. The wall work employed a lightweight brick wall design alternative.

Table 3Comparison of the initial planned RAB with the VE RAB

No	Work Items	Cost (Rp)	
		Initial Cost	Cost VE
1	**Work structure** (composite beam and column work is replaced with conventional beams and columns)	**9,617,752,350**	**6,046,462,020**
2	**Work foundation**	**3,886,371,093**	**3,886,371,093**
3	Preparation	245,100,000	245,100,000
4	Site Management	280,000,000	280,000,000
5	Document Project	15,000,000	15,000,000
6	Crane Rental	100,000,000	100,000,000
7	K3 costs	55,300,000	55,300,000
8	Waterproofing Work	80,792,712	80,792,712
9	Work floor	1,366,105,250	1,366,105,250
10	**Work wall** (red brick wall work is replaced with lightweight bricks)	**1,996,268,271**	**1,926,079,060**
11	Ceiling work	509,501,405	509,501,405
12	Skylight work	101,885,000	101,885,000
13	Roof slab screed work	59,900,000	59,900,000
14	Work door	183,068,400	183,068,400
15	MEP Work	4,624,261,120	4,624,261,120
	Total price	**23,121,305,602**	**19,479,826,062**

From Table 2, it can be seen that the initial Cost was Rp. 23,121,305,602, then the Cost VE was Rp. 19,479,826,062. It can be concluded that after the VE was carried out, it was able to save costs of Rp. 3,641,479,540 or 15.75 % of the total cost. RAB awal.

CONCLUSION

Based on results and discussions that have been done so obtained conclusion as following:

Based on the Pareto analysis, there are three work items with a cumulative cost of 80% of the total project cost: concrete structure work, foundation work, and wall work. The foundation work continues to use a bore pile foundation because this method is most appropriate for the project's very limited conditions due to the store's operational conditions and high customer mobility. Therefore, the work with potential for value engineering analysis is the concrete structure work and wall work.

1. The cost savings after value engineering (VE) were Rp 3,641,479,540, or 15.75% of the initial Budget Plan. The best alternatives for each work item were:
   a. Work Structure

The initial plan for the structural work is composite columns and beams. as well as plate metal deck, then replaced with alternative design namely the column and beam conventional with plate metal deck. The initial Cost Budget Plan for the structural work was Rp 9,617,752,350, after analysis, the Cost VE was Rp 6,046,462,020 with a cost savings of

37.1% from the cost for the structural work.

b. Work Wall

The initial plan for the wall work was to use red brick walls, which were then replaced with an alternative design, namely lightweight bricks. Plan Budget Cost beginning work wall that is Rp. 1,996,268,271, after the analysis, the cost VE was Rp. 1,926,079,060 with cost savings of 3.516% from the RAB for wall work.

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