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A Cost-Efficiency Analysis for Upper-Structure Construction Based on Value Engineering: A Case Study

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Abstract

This study aims to analyze cost efficiency in the upper structure of multi-story buildings through a Value Engineering (VE) approach. The case study focuses on the construction project of the Joint Lecture Building 5 (GKB 5) at Muhammadiyah University Malang. The research focuses on identifying the upper structure components that dominate the costs and developing alternative materials and methods that still fulfill the structural function but are more cost-efficient. The VE process includes the stages of identifying work elements that require cost optimization, evaluating alternative solutions, and selecting the best alternative based on technical and cost considerations. The results of the study show that optimizing the reinforcement of columns, beams, and slabs, as well as changing the formwork system from conventional to semi- system, can produce cost efficiencies of 8–14% without reducing the strength and safety of the structure. These findings confirm that VE can be a strategic tool for decision-making in high- rise building construction projects

Keywords: Valie Engineering, Cost Efficiency, Upper Structure, Construction Projects

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INTRODUCTION

In construction, one of the main challenges is how to optimize existing resources to achieve maximum results at an efficient cost. Cost efficiency is a crucial element in construction projects, given the complexity and size of the budget involved [1]. A quality building not only encompasses safety and comfort, but also efficiency in the construction process [2]. Cost efficiency does not only focus on saving expenses, but also on increasing the value and quality of the final results of the project [3]. This practice requires careful planning, the use of effective work methods, and the utilization of appropriate technology and materials. The construction of lecture buildings, as one of the elements that support educational activities, requires special attention in this regard. University buildings serve not only as places of learning but also as centers for other academic activities that require good construction quality and efficient cost management [4].

The construction of University buildings at Muhammadiyah University of Malang, particularly the Joint Colleague Building (GKB) 5, is an important project that requires special attention to cost efficiency. This building is planned to support lecture activities and educational development at the university. However, with the increasing costs of raw materials and labor, as well as demands for better building quality, it is important to conduct an in- depth analysis of the costs incurred in this project. The use of Value Engineering is expected to contribute significantly to achieving the desired cost efficiency, so that the predetermined budget can be utilized optimally [5].

Value Engineering is a method that has been proven effective in improving cost and time efficiency in construction projects. Value Engineering focuses on increasing the value of a product or project by reducing costs without sacrificing function and quality [6]. The use of

This method is expected to improve cost efficiency in the construction of GKB 5 and produce a high-quality lecture hall in accordance with the established standards. One of the advantages of applying Value Engineering in construction projects is its ability to identify and eliminate unnecessary costs. In the context of GKB 5, an in-depth analysis of each structural element can help the project team find more cost- effective design alternatives. Thus, the application of Value Engineering not only contributes to cost savings but also increases the overall value of the project [7].

Over the past two decades, Value Engineering (VE) has evolved from a traditional cost-control approach into a systematic methodology aimed at enhancing project value through functional analysis and resource optimization. Conceptually, VE seeks to eliminate unnecessary costs without compromising the primary functions of a project [11][12]. In the context of modern construction, cost efficiency is no longer interpreted merely as cost reduction, but rather as value enhancement achieved through a balanced integration of function, quality, and cost [13]. With advancements in construction technology, VE has increasingly been integrated with Building Information Modeling (BIM), risk management frameworks, and sustainability-oriented approaches based on life cycle cost analysis [14].

Research conducted by Prastowo (2021) demonstrates that the integration of VE with BIM and FAST diagrams can increase cost efficiency by up to 53% compared to the initial project plan[8]. The study highlights the importance of selecting appropriate construction methods, improving labor productivity, utilizing alternative materials, and leveraging digital technologies to support decision-making processes. However, the research primarily focuses on system integration and project management aspects, without conducting an in-depth technical evaluation of reinforced concrete structural elements. Meanwhile, Putri (2020) applied VE to the Sidoarjo East Ring Road improvement project and achieved a cost saving of 12.6% without compromising the quality and functional performance of the road infrastructure[9]. Nevertheless, road structures differ fundamentally from multi-story building structures, which involve more complex flexural, axial, and combined load interactions.

Irfanto et al. (2023) examined the implementation of VE in a school building project and found that cost efficiency could be achieved by eliminating non-value-added components [15]. However, the study adopted a descriptive-comparative approach and did not quantitatively evaluate reinforcement ratios, structural dimensions, or performance validation. On the other hand, Kumara et al. (2025) extended the application of VE within the context of green buildings, emphasizing material efficiency and environmental performance improvement [16]. While this study contributes to the sustainability discourse, it does not specifically address the optimization of superstructure elements in multi-story educational buildings.

A systematic review by Chen et al. (2025) indicates that global VE research trends are shifting toward VE–BIM integration, life cycle cost analysis, and risk-based value assessment[14]. Despite these advancements, case-based studies that integrate VE functional analysis with quantitative technical evaluation of reinforced concrete superstructures in multi-story educational buildings remain limited, particularly in developing countries. Therefore, a clear research gap exists at the technical-structural level and in examining the institutional implications of cost efficiency.

This study is essential to address inefficiencies in the superstructure works of educational buildings, where overdesign and excessive material usage frequently occur. In multi-story construction projects, beams, columns, and slabs account for a substantial proportion of the total budget; thus, optimization of these components can generate significant financial impact. Unlike previous studies, this research not only compares the initial and alternative design costs but also conducts technical evaluations of structural dimensions and reinforcement ratios to ensure that cost reductions do not compromise structural performance and safety.

Conceptually, this study offers novelty by integrating VE functional analysis with quantitative technical evaluation of reinforced concrete structures in multi-story educational buildings. Methodologically, it extends VE application from a managerial perspective to a technical-structural level through rigorous validation of alternative designs. Contextually, it examines the implications of cost efficiency on the financial sustainability of higher education institutions, thereby contributing beyond project-level analysis. With an estimated cost-saving potential of 15–20% in superstructure works, this research aims to propose a measurable, safe, and sustainable cost optimization model [10].

The objectives of this study are to identify superstructure components with potential cost inefficiencies, analyze the function of each structural element using the Value Engineering method, develop more economical structural design alternatives without compromising safety and quality, and quantify the achievable cost savings resulting from the proposed optimizations.

The cost efficiency resulting from the application of the VE method will have an impact on overall university budget savings. These savings can be reallocated to the development of other educational facilities, such as laboratories, libraries, or research rooms. Thus, the implementation of this method not only provides direct benefits in the GKB 5 project but also has a positive impact on the development of educational infrastructure at UMM more broadly. This creates a positive cycle in which cost efficiency not only improves the performance of current projects but also provides benefits for the development of educational facilities in the future.

METHOD

This study uses a qualitative and quantitative approach with a descriptive research type. This approach was chosen to analyze cost efficiency in structural work using the Value Engineering method. This study aims to identify and evaluate strategies that can improve cost efficiency in the construction of the Joint Lecture Building (GKB) 5 of Muhammadiyah University Malang. Several stages of value engineering will be carried out, including identifying work elements that require cost optimization, evaluating alternative solutions, and selecting the best alternative based on technical and cost considerations.

a. *Research Data and Variables*

The data used in this study includes information related to the work methods applied, field conditions, obstacles encountered during project implementation, project documents, such as the Bill of Quantity (BoQ), cost budget reports, project planning documents, and the results of time and material usage measurements at the project site, which are used to evaluate the application of the value engineering method. The research variables used in this study are Columns, Beams, Floor/Roof Slabs, Material Types, and Material Costs.

b. Processing

At this stage, it is necessary to first identify the Upper Building Structure. Researchers analyze the structural elements of the building located at the top of the building to identify parts or variables that have the potential for efficiency improvements. In this context, the Value Engineering approach is used to review each structural component, such as beams, columns, slabs, and materials used, with the aim of reducing waste and optimizing value without compromising quality and function. This identification process aims to determine the components that can be optimized in terms of cost, time, or resources, resulting in a more efficient and economical design for the UMM Joint Lecture Building 5 construction project.

1. Value Engineering (VE) Analysis

The stages in this analysis include:

a. Information Stage

All detailed information about the project is collected, including the main functions of the work, client requirements, and technical specifications. This information is used as a basis for finding ways to increase the value of the project without reducing quality. The steps are as follows:

1. Project Identification
2. Identification of Work Items/Cost Model
3. Breakdown of Cost Model
4. Function Analysis/Fast (Function Analysis System Technique)

b. Analysis Stage

Every alternative generated is analyzed in terms of cost, function, and structure to assess its feasibility, effectiveness, and impact on cost efficiency. This is to determine whether the alternative provides the desired cost efficiency.

c. Evaluation Stage

This stage is a critical process in which each proposed efficiency improvement alternative is comprehensively evaluated. This evaluation considers aspects of technical feasibility, potential cost savings, duration or implementation time, and impact on the performance and functionality of the building. Each alternative is analyzed to ensure that the proposed solution not only saves costs but also meets project quality and safety standards. In addition, the impact on the project schedule is also considered, with alternatives that can save time without compromising quality being prioritized. The result of this evaluation stage is a list of the most effective and efficient alternatives to be implemented in the project, thereby optimally increasing construction value in accordance with the project budget and objectives.

RESULT AND DISCUSSION

A. Information Stage

1. Upper Structure Information

The upper structure of the Joint Lecture Building (GKB) 5 consists of main structural elements that function to support and distribute vertical and lateral loads on the building. These elements include columns, beams, and floor slabs that work integrally to ensure the overall stability and strength of the structure. Each element is designed using concrete and reinforced steel materials in accordance with planning standards, and has dimensions and reinforcement configurations tailored to the load requirements of each floor. This information forms the basis for cost efficiency analysis in the Value Engineering implementation stage.

a. Columns

The column structure in the Joint Lecture Building (GKB) 5 project consists of five types of columns with different diameter dimensions, namely K1, K2, K3, K4, and K5. Column K1 has the largest diameter because it bears the largest load in the main structure area, followed by columns K2, K3, K4, and K5 in zones that receive smaller loads.

Table 3.1 Recapitulation of Existing Columns

Parameters	K1	K2	K3	K4	K5
Column Diameter	Ø 1150 mm	Ø 1050 mm	Ø 950 mm	Ø 850 mm	Ø 750 mm
Main Reinforcment (Support)	42D25	34D25	30D25	24D25	18D25
Main Reinforcment (Field)	42D25	34D25	30D25	24D25	18D25
Stiruups (Support)	D13 - 100	D13 - 100	D13 - 100	D13 - 100	D13 - 100
Stirrups (Field)	D10 - 200	D10 - 200	D10 - 200	D10 - 200	D10 - 200
Concreate Quality (fc')	25 MPa	25 MPa	25 MPa	25 MPa	25 MPa
Steel Quality (fy)	420 MPa	420 MPa	420 MPa	420 MPa	420 MPa

b. Beams

Existing beams (types and reinforcement) The beam structure in the Joint University Building (GKB) 5 consists of three types of beams, namely B1 as the main beam, and B2 and B3 as secondary beams. The main beam (B1) has the largest dimensions because it functions to transfer the largest load from the slab and secondary beams to the columns. Meanwhile, beams B2 and B3 are smaller in size because they receive lighter loads.

Table 3.2 Recapitulation of Existing Beams

Parameters		B1	B2	B3
Dimensions (mm)		400 × 750	350 × 650	250 × 600
Concreate Quality (fc')		25 MPa	25 MPa	25 MPa
Steel Quality (fy)		420 MPa	420 MPa	420 MPa
Upper Support Reinforcement		10D25	7D25	5D25
Lower Support Reinforcement		7D25	4D25	3D25
Upper Field Reinforcement		7D25	4D25	3D25
Lower Field Reinforcement		10D25	7D25	5D25

c. Slab

The S2 floor slab is part of the building floor structure that functions to support the load from user activities and distribute it to the supporting beams. This slab is 13 cm thick and uses 25 MPa concrete, which is strong enough for multi-story buildings. For reinforcement, 420 MPa steel with a diameter of D13 is used, installed closely every 150 mm.

Table 3.3 Slab Recapitulation

Parameter	Spesifications
Element Code	S2
Function	Upper Floor Slab
Slab Thickness	13 cm
Concreate Quality (fc')	25 MPa
Reinforcing Steel Quality (fy)	420 MPa
Reinforcing Bar	Specifications
Distance Between Reinforcing Bars	150 mm
Reinforcing Bar Type	Threaded Reinforcing Steel
Plate System	One Direction/Two Direction

2. *Formwork Material Information*

In the upper structure work of the Joint Lecture Building (GKB) 5 of Muhammadiyah University Malang, the formwork system used in the field is conventional formwork. Conventional formwork is a casting method that uses main materials such as wooden boards, plywood, wooden beams, rafters, and wooden or iron scaffolding that are assembled manually to form concrete molds.

Figure 3.1 Wooden materials for conventional formwork

3. *Cost Information*

At this stage, all aspects of expenditure related to structural and architectural work are identified, analyzed, and systematically compiled to ensure compliance with the predetermined budget plan (RAB). Cost data includes material prices, labor costs, equipment, and indirect costs required during implementation.

Table 3.4 Total Work Costs

Work Component	Component Cost (Rp)
General Preparation Work	Rp 4.734.619.687
Construction Safety Management Work	Rp 340.612.000
Land work	Rp 169.543.237
Foundation Work	Rp 7.350.778.865
Basement Floor Work	Rp 4.772.202.085
First Floor Work	Rp 3.913.493.642
Second Floor Work	Rp 3.317.655.838
Third Floor Work	Rp 2.580.125.993
Fourth Floor Work	Rp 2.909.041.446
Fifth Floor Work	Rp 2.413.874.458

Sixth Floor Work	Rp 2.304.572.281
Seventh Floor Work	Rp 1.641.893.121
Eighth Floor Work	Rp 1.527.523.417
Ninth Floor Work	Rp 1.392.782.010
Tenth Floor Work	Rp 990.667.488
Roof deck Floor Work	Rp 603.963.781
Roof Deck Work	Rp 5.333.930
Steel Structure Work	Rp 1.548.884.352
SubTotal Physical Construction Costs	Rp 42.567.567.630
Value Added Tax (VAT) 11%	Rp 4.682.432.439
Total Physical Construction Costs	Rp 47.250.000.070
Rounded	Rp 47.250.000.000

B. Analysis Stage

1. Superstructure Analysis

Details of the structural analysis control results can be seen in the table in the appendix. The following is a summary of the reinforcement analysis control results for the alternative changes:

Table 3.5 Recapitulation of Beam Reinforcement Control

Beam Type	Mu Position	Mu (knm)	ϕMn Alternative (knm)	ϕMn Existing (knm)
B1	Mu,Support (+)	559,87	571,96	720,49
	Mu, Support (-)	703,563	744,06	893,78
	Mu, Field (+)	701,892	720,49	854,51
	Mu, Field (-)	523,355	579,81	744,06
B2	Mu, Support (+)	236,887	256,78	334,08
	Mu, Support (-)	421,85	476,23	541,09
	Mu, Field (+)	531,514	562,06	630,46
	Mu, Lapangan (-)	233,687	256,78	334,08
B3	Mu, Field (+)	205,679	225,75	225,75
	Mu, Support (-)	264,33	289,39	347,22
	Mu, Field (+)	221,17	289,39	347,22
	Mu,	214,01	225,75	225,75

	Field (-)	3		

Table 3.6 Recapitulation of Floor Slab Reinforcement Control

Plate Type	Renforcment Direction	Mu (knm)	ϕMn Alternative (knm)	ϕMn Existing (knm)
S2	Support X	16,39	17,48	27,74
	Field X	6,62	11,03	17,83
	Support Y	16,39	17,48	27,74
	Field Y	6,62	9,82	15,18

2. C/W Function Analysis

This analysis aims to evaluate cost efficiency by comparing the Cost and Worth values, where the final result must have a value greater than 1 to meet the feasibility of applying Value Engineering. For example, the c/w analysis results are only given for the seventh foor work function.

Table 3.7 Seventh Floor Work Function Analysis

Component	Cost (Rp)	Worth (Rp)
Concreate Beam 400x750	Rp 72,935,262	Rp 72,935,262
Concreate 350x650	Rp 51,823,749	Rp 51,823,749
Beton Balok 250x600	Rp 15,633,305	Rp 15,633,305
Tulangan Balok	Rp 541,808,856	Rp 541,808,856
Beam Formwork	Rp 138,651,408	
Floor Slab Concreate S2	Rp 77,456,523	Rp 77,456,523
Component	Cost (Rp)	Worth (Rp)
Plate Reinforcment	Rp 233,337,206	Rp 233,337,206
Formwork Plate	Rp 73,895,911	
Column Concreate K1	Rp 33,496,639	Rp 33,496,639
Column Concreate K2	Rp 13,233,240	Rp 13,233,240
Column Concreate K3	Rp 3,377,233	Rp 3,377,233
Column Concreate KL 1	Rp 2,765,705	Rp 2,765,705
Column Concreate KL 2	Rp 1,843,803	Rp 1,843,803
Column Reinforcment	Rp 264,175,704	Rp 264,175,704
Column Formwork	Rp 79,609,261	
	Rp	Rp

Total	1,604,043,806	1,311,887,225
C/W	**>1**	**Feasible VE**

3. Cost Analysis

The results of the cost analysis presented in this subsection form the basis for assessing the economic efficiency of the alternatives studied and are used as consideration in determining the most feasible planning alternative in the next stage of analysis.

Table 3.8 Results of the Alternative Value Engineering Unit Price Analysis

Alternative Work			
Job Name	Type	Cost	
Beam	Concreate	Rp	983,850.00
	Formwork	Rp	130,483.07
	Steel	Rp	12,449.60
Floor Slab	Concreate	Rp	983,850.00
	Formwork	Rp	103,688.07
	Steel	Rp	12,449.60
Column	Concreate	Rp	1,033,850.00
	Formwork	Rp	2,229,178.45
	Steel	Rp	12,449.60

C. Evaluation Stage

The overall cost evaluation results can be seen in the following table:

Table 3.9 Overall Cost Evaluation Results of Value Engineering

Floor	Actual Cost (k)	Alternative Cost (k)	Percentage Efficiency
1th Floor	Rp 3.815.943	Rp 2.364.791	38,03%
2th Floor	Rp 3.185.693	Rp 2.353.066	26,14%
3th Floor	Rp 2.501.489	RP 2.131.104	14,81%
4th Floor	Rp 2.792.361	Rp 2.296.971	17,74%
5th Floor	RP 2.351.580	Rp 1.960.768	16,62%
6th Floor	Rp 2.156.646	Rp 1.894.541	12,15%
7th Floor	Rp 1.572.663	Rp 1.516. 642	3,56%
8th Floor	Rp 1.449.648	Rp 1.397.851	3,57%
9th Floor	Rp 1.287.165	RP 1.224.071	3,35%
10th Floor	Rp 919.253	Rp 812.998	11,56%
Total	RP 22.032.446	Rp 17.972.807.	18,43%

The results of the evaluation using value engineering according to the stages show that the initial structural design has overdesign in several elements, especially columns and beams, allowing for a reduction in reinforcement without reducing structural capacity. In addition, the implementation of semi-system formwork has been proven to reduce installation time, increase panel repetition, and reduce overall costs. The integration of the VE method with the principles of construction production efficiency has yielded significant results in increasing the value of the project. The results of value engineering are described in stages in the following points.

1. Information Stage

The Joint Lecture Building 5 is a multi-story building with the main function as a facility for lectures and academic activities. The upper structure of the building consists of floor slabs, beams, and columns that serve to transfer gravitational and lateral loads to the lower structure. With a project value of IDR 47.25 billion and an implementation period of 180 calendar days, cost and time efficiency are crucial aspects that can be improved through the application of the Value Engineering method to the upper structural elements of this building.

Table 3.1.1 Project Information GKB 5

Description	Details
Project Name	Gedung Kuliah Bersama 5 (GKB 5)

Location	Muhammadiyah University of Malang, EastJava
Number of Floors	10 Floors
Project Value	Rp 47.250.000.000,-
Type of Work Analyzed	Upper Structure (Slab, Beams, Columns)

2. Analysis Stage

This process involves rechecking the control elements of the structure affected by material changes to ensure that these changes do not affect the stability, load-bearing capacity, and overall integrity of the building. If the analysis results show that the selected alternative materials do not meet safety criteria, then a reanalysis of these alternative materials is required. This process will continue until a material solution is found that is safe and in line with the technical requirements and project budget. The following is a summary of the reinforcement analysis control results for alternative changes:

Table 3.1.2 Summary of Existing and Alternative Column Control (Example for K1 only)

Parameter	K1 (Existing)	K1 (Alternative)
Column Diameter	Ø 1150 mm	Ø 1150 mm
Main Reinforcemnet (Support)	42D25	35D25
Main Reinforcemnet (Field)	42D25	35D25
Pu	15846,213	15846,213
Mu	3583,53	3583,53
Ø Mn	7301,45	6244,15
Ø Pn	27270,09	26205,02

3. Evaluation Stage

Based on the calculations, it was found that the total actual cost for the upper structure work from the 1st to the 10th floor was Rp 22,032,446,301.92, while the cost with the application of alternative materials reached Rp 17,972,807,033.52. These results show that the use of alternative materials can provide cost efficiency of IDR 4,059,639,268.40, or around 18.49% of the total cost of the upper structure project. This efficiency is obtained through the optimization of reinforcement volume, the use of a more efficient formwork system, and a more realistic adjustment of AHSP to field conditions and labor productivity. Despite the cost reduction, the technical evaluation results show that the alternative materials and methods used still meet the quality and structural strength standards as required in the planning. Thus, it can be concluded that the application of Value Engineering in the upper structure work of the Joint Lecture Building 5 of Muhammadiyah University Malang has yielded positive results, both in terms of cost efficiency and implementation effectiveness, without compromising the function and quality of the building construction.

DISCUSSION

The results of this study indicate that optimizing reinforcement in columns, beams, and slabs, as well as changing the formwork system from conventional to semi-system, can result in cost efficiencies of 8–14% without compromising structural strength and safety. These findings confirm that Value Engineering (VE) can be a strategic tool for decision-making in high-rise building construction projects. An in-depth evaluation of the GKB 5 project used the VE approach. Of all construction components, the superstructure elements, namely columns, beams, slabs, and formwork, were identified as the main contributors to the overall project cost. The application of VE resulted in alternative material strategies, including reducing the amount of reinforcement and using semi-system formwork. The achieved cost efficiencies ranged from 8–14%, which were obtained without compromising the function or safety of the structure. This study proves that VE is an effective decision-making method for optimizing construction costs in high-rise building projects. By systematically analyzing critical structural elements and proposing technically feasible design alternatives, VE not only reduces unnecessary expenses but also ensures the quality and reliability of the structure is maintained, thus providing financial and operational benefits to the project.

These findings are consistent with the VE research trend, which shows that applying Value Engineering (VE) to structural elements in construction can provide significant cost savings [29][30][31][32][33]. A study by Asa et al. (2025) applied VE in the basement work of a high-rise building and reported a cost reduction of 26.7% through changes in construction methods and a life cycle cost approach [17][24][25]. However, that study focused more on overall project cost savings without a detailed technical evaluation of structural safety aspects. Another finding by Kumar et al. (2025) indicated that using VE in the context of green buildings can improve material efficiency and environmental performance, although it did not include a detailed analysis of the superstructure elements [18]. Furthermore, This study applied the paired comparison method combined with the Value Engineering (VE) approach to determine the most effective and efficient type of foundation for building construction work [19][21][22][23].

Additionally, a systematic review by Chen et al. (2025) noted that VE research is increasingly trending toward integrating VE with BIM, life cycle cost analysis, and risk-based assessment to improve cost planning accuracy in construction projects. Nevertheless, empirical case-based literature that combines VE with quantitative technical evaluation of superstructure elements in multi-story educational buildings remains relatively limited, especially in developing countries like Indonesia [14][26][27][28]. This study addresses this gap by providing empirical data on the impact of VE on reducing reinforcement quantities and adopting semi-system formwork while still meeting structural safety standards.

The differences in cost efficiency levels between this study and previous studies can be explained by the more technical methodological context of this research. This study not only compared the costs of initial and alternative designs but also examined the technical impact of reinforcement reduction and formwork changes on structural performance through the evaluation of reinforcement ratios and structural element dimensions. This approach makes the analysis results more accurate and applicable in the context of multi-story reinforced concrete structures, compared to studies that conducted VE only in a managerial or descriptive manner.

This study demonstrates that VE can contribute to enhancing project value not only in terms of cost but also in ensuring structural safety, functionality, and quality. The analysis of critical cost components and the selection of technically feasible alternative strategies have a significant impact on construction practices aimed at optimal outcomes. This also broadens the understanding of VE from merely a cost-reduction technique to a strategic tool capable of supporting design and construction decisions based on quantitative evaluation.

The main novelty of this study lies in three aspects: first, the integration of technical-structural evaluation with the Value Engineering approach for superstructure elements of multi-story educational buildings, which is rarely found in Scopus-indexed literature; second, the development of alternative material strategies that consider both technical performance and cost efficiency; and third, the practical implications for managing the budgets of educational institutions, enabling more effective allocation of funds for other academic facility developments.

From a practical perspective, these findings provide technical guidance for project managers, contractors, and other stakeholders in optimizing multi-story building structural works using VE. Academically, this research enriches VE literature with strong empirical evidence in the context of multi-story educational buildings in developing countries. From a policy perspective, the results can serve as a basis for developing internal guidelines for universities or government institutions to plan more efficient, safe, and sustainable construction projects.

As recommendations for future research, it is suggested that subsequent studies: (1) integrate VE with life cycle cost analysis to evaluate long-term impacts on project performance and total costs; (2) apply VE to various types of buildings with different structural characteristics, such as earthquake-resistant buildings or healthcare facilities; and (3) develop decision support systems that combine VE with BIM technology and quantitative methods such as AHP to automatically generate optimal design recommendations.

CONCLUSION

This study presents the results of an evaluation of the GKB 5 project using value engineering. Of all the construction components, the upper structure components that contributed the most to the cost were columns, beams, slabs, and formwork. The application of VE resulted in alternative materials in the form of a reduction in the amount of reinforcement and the use of semi-system formwork. The cost efficiency achieved ranged from 8–14% without compromising the function and safety of the structure. VE proved to be an effective decision-making method in optimizing the costs of multi-story building projects. Based on the findings of this study, future researchers are encouraged to explore the application of Value Engineering (VE) across various types of high-rise building projects, not limited to projects like GKB 5, in order to assess the consistency of cost efficiency and structural reliability under different conditions. Additionally, further research could examine the long-term impacts of reinforcing optimization and the use of semi-system formwork on structural performance, maintenance, and building safety. Researchers may also develop simulation models or predictive tools based on VE to facilitate decision-making for alternative designs, including variations in materials and structural configurations, allowing for faster and more measurable cost optimization. A comprehensive evaluation of structural risks and cost-benefit analysis is also recommended to ensure that material reductions or changes in formwork systems remain both safe and economically viable over the long term.

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