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THE APPLICATION OF VALUE ENGINEERING ANALYSIS IN FAÇADE CONSTRUCTION: A CASE STUDY OF SIX STOREY BUILDING FACADE

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A B S T R A C T

Value engineering analysis is a methodical approach used to find and eliminate superfluous expenses within various domains such as projects, processes, and the construction industry, with the aim of improving both quality and performance. In order to achieve a harmonious equilibrium between time, money, and quality, the present circumstances and methodologies within the construction sector of Myanmar necessitate a substantial amount of dedication and exertion. Due to this rationale, value engineering (VE) is an established management approach that facilitates the enhancement of project value and the realization of cost savings in construction projects. The objective of this study was to identify alternative materials that are more cost-effective than the original design for the exterior of the hospital building, while ensuring that the chosen materials retain their inherent value. Based on the findings of the study, the implementation of value engineering techniques resulted in a cost reduction of up to 7.6 percent for the façade work. This research assesses the financial benefits derived from the use of Value Engineering (VE) in a six-story hospital located in Yangon. The study specifically focuses on the utilization of materials of intermediate grade for the facade construction. This research endeavor aims to contribute to the existing corpus of knowledge on value engineering by conducting a comprehensive analysis of a specific case study.

1. INTRODUCTION

The size, complexity, and dynamic nature of the construction industry act as a gauge of a nation's economic development (Behm, 2008). An important part of project management while developing a building project is keeping project expenditures under control (Zahoor et al., 2022). One of the methods is through utilizing the value engineering process (VE) (Berawi, 2014). VE is a decision-making process that is based on a systematic, multidisciplinary approach. Its effectiveness is measured by looking at the function that maximizes a project's value. The best benefit of a project may be attained by determining the functions necessary to achieve the intended target value. Additionally, VE provides these services at the most affordable rates while

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still maintaining the necessary standards of quality and performance (Hammersley, 2002). A building's façade is frequently its front or outside. It is generally vertically oriented and includes its supporting parts (Bricks, 2018).The facade, which provides the building its unique shape and attractiveness, is among the most crucial elements of the structure's overall design (ASTI, 2021).

The many benefits that Value Engineering has contributed to construction projects have made the building industry more competitive across a variety of countries. One advantage of VE is that it might influence decisions made throughout the design process, resulting in more effective cost reductions (Robinson, 2008). Building facades cost between 15 and 40 percent of the entire cost of construction (Hammersley, 2002). Hence the optimum cost for facade work on a building project may be determined using VE. Although VE's expansion there is moving incredibly slowly, it is positive that awareness of VE exists in Myanmar's building sector. In in order to demonstrate and highlight the value engineering analysis efficiency in the construction business, the researcher employs a case study. For the case study on VE practices, HtetMyatArkar (HMAK) firm provided the information and data. The case study focuses on the façade of a six-story hospital building that was constructed in Yangon, Myanmar.

2. BACKGROUND OF THE STUDY

Because of new materials, improved production processes, and technological advancements, facades frequently adopt new shapes and styles (Dell'Isola, A. 1997).. The main issues with facades are technical and buildable when new technology is employed for installation or building integration (Saeedi & Kavian Pour, 2017). Value engineering has a very longstanding history that begins with the shortage of materials during World War II. The theory was developed by Lawrence D. Miles, a worker with the General Electrical Company. Prior to being embraced by the construction industry, value engineering was used in the industrial sector (Massachusetts, 2001). Building construction projects typically run over budget because of the inappropriate use of resources and the completion of work ahead of schedule. Using VE, one may avoid these problems and cut expenses while preserving the worth and caliber of the replaced item. The entire cost of the project can be decreased as a consequence.

According to other literature and VE studies, the VE results in reduced project costs without sacrificing the quality and usefulness of the materials. Arumsari and Tanachi (2018) are analysis with the VE in architectural work of a high- rise building in Bali, Indonesia and they saved the 8% of the total cost of architectural work. Another case study from College of Transportation and Civil Engineering, Fujian Agriculture and Forestry University, Fuzhou, Fujian Province, China, 10% of the project cost are saved by using BIM and VE integration in high-rise building project from China (Ramani & Pitroda, 2018). In order to better comprehend the use of VE in the construction sector in Myanmar, the researcher identifies a nearby company that employs VE and approaches them for information on VE practices. One of the top firms in Myanmar for the construction of facades is HtetMyatArkar. The HMAK firm was established in 2010, and in 2018 it started using VE analysis. The researcher chose a six-story hospital building façade project that was finished in May 2022 as the case subject for the investigation (Zahoor et al., 2022).

Research Aim

The aims of the research are following:

- To study the concept and application of value engineering in construction industry
- To identifying high cost areas and unnecessary cost in façade project.
- To establish alternative ways for cost reduction of high cost functions by creative techniques.
- To Improving value delivered by the facade project.

3. LITERATURE REVIEW

3.1 Value Engineering (VE)

Value Engineering (VE) is one of the useful methods for finding solutions, eliminating wasteful spending, and improving function and quality. The value engineering process consists of many organized steps that are intended to optimize both short- and long-term investment while delivering the greatest value at the lowest cost (Dickson et al., 2009). Value engineering (VE) has long been used in the building sector. It provides a detailed and in-depth analysis of how to achieve a project's goals as a technique. Its objective is to determine a project's optimum value, both now and in the future. By analyzing prices and resources available, it seeks to do a task to a great value at the most affordable price possible (Kelly et al., 2004).

Value engineering requires collaboration. Aspirations for architectural design are purportedly dashed during the value engineering process. Value engineering, though, may really be advantageous to all parties concerned, including manufacturers of building products, architects, and designers. There are several benefits to embracing and actively participating in value analysis, and creativity may be employed in a variety of ways to achieve project goals (Walangitan & Kembuan, 2016). A variety of project stakeholders, including as architects, designers, cost estimators, engineers, builders, and project managers, are involved to generate the best outcome. The value engineering process consists of the following six steps:

- Information phase
- Function analyzing phase
- Creativity phase

- Evaluation phase
- Decision analyzing phase
- Decision making phase

In order to add value to a system, product, or service, value engineering is the "function-oriented, systematic, team approach," according to the SAVE International (Society of American Value Engineers). Three essential factors—function, quality, and cost—are required to measure a value goals (Walangitan & Kembuan, 2016). Equation 1 shows the relationship between the components.

$$\text{Value} = \frac{function+Quality}{Cost} \quad (1)$$

3.2 Value

In value engineering, the economic value is priorities and comprises of 4 categories as followed:

- Cost value, which is the sum of the costs of labor, materials, equipment, and overhead in producing an item;
- The worth that is exchanged is called exchange value. A buyer who is inspired to purchase a thing is referred to as worth. This price is decided by the current market price;
- The owner or user's willingness to pay for a prestige is decided by the esteem value of that prestige. This value relates to the user's requirements and preferences;
- Use value is the functional value of a system, method, or product that is designed to achieve a certain goal (Dehmourdi & Ebrahimi, 2014).

3.3 Function

Function is the main focus of a value engineering (VE) examination. Value engineering aims to deliver a system with the necessary characteristics for the lowest possible cost. The functions in VE are important since they are the main object linking them to the cost. Function can be divided into the two groups listed below:

- A product's fundamental purpose, which also serves as a foundation or justification for its existence, and which has utility value
- A secondary function is one that is required to sustain fundamental requirements but is not directly employed to meet those needs (Berawi, 2014).

3.4 Cost

A project or product's cost is the sum of all the expenses incurred during development and production. A product or an project's profitability is always determined by how decisions for dependability, reliability, and maintenance affect the project's cost. According to the link between function, quality, and cost, an unnecessary expense is one reason for a low value goals (Walangitan & Kembuan, 2016).

3.4 Pareto Analysis

The idea behind Pareto analysis is that a tiny proportion of fault categories will contribute for a sizable proportion of overall faults. Although some claim that a 90/10 split is more common, Pareto's 80/20 rule, which asserts that 20% of fault types account for 80% of all flaws, is usually correct (Arumsari & Tanachi, 2018), This allows for the most significant issues to be identified and addressed with the least amount of effort.

3.5 Cost-to-Worth Analysis

The fundamental theory of value, known as cost-to-worth, describes the relationship between cost and worth (Berawi, 2014).

The equation for cost to worth is:

$$\text{Cost} - \text{to} - \text{Worth} = \frac{\text{Cost}}{\text{Worth}} \quad (2)$$

The high cost-to-worth ratio indicates that a system has the potential to save a lot of money. Cost-to-worth ratios greater than 1 indicate the prospect of cost reductions (Phyo & Cho, 2014).

3.6 Life-Cycle Costing

Value engineering's life-cycle costing technique provides a detailed economic analysis of competing choices to achieve goals. The analysis identifies the least expensive options for a project or purchase throughout the duration of its useful or serviceable life and assesses prospective initial investments. Life-cycle costing examines the associated ownership costs of competing choices by discounting both the positive and negative cash flows during the facility's service life (Li et al., 2021.)

4. METHODOLOGY

The case study for the six-story hospital building façade project in Yangon, Myanmar, served as the basis for this research's state-of-the-art analysis. Through a value engineering study, just the façade work will be examined. The research methodology is depicted in the flowchart below.

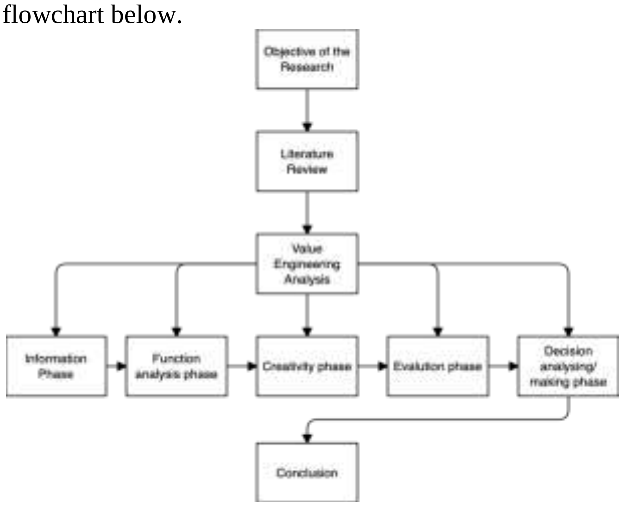

Figure 1: Research Methodology Flow Chart Case Study

4.1 Information Phase

The first stage of the value engineering is information phase. Information on the project's origins, design, potential hurdles, and cost is gathered (Arumsari & Tanachi, 2018). The six-story hospital building's exterior makeover cost 25% of the total cost of the structure. According to the Pareto law, value engineering may be utilized to further assess facade work; however, only cumulative costs up to 80% will be further investigated. Work on the doors and windows, curtain walls, bio-wood, composite materials, concrete cornice, metal guards, roll-up doors, and glass sunshades are all included in the façade work on the six-story structure. The Pareto analysis and the specifics of the building's facade budget are displayed in Table 1.

Table 1. Six Storey Hospital Building's Façade Budget and Pareto Analysis

No	Scope of Work	Budget (MMK)	Percentage Cost	Cumulative Percentage
1	Door and window	31,000,000	31	31
2	Curtain Wall	32,300,000	32.3	63.3
3	BioWood	12,000,000	12	75.3
4	Glass Sunshade	8,000,000	8	83.3
5	Metal guard	6,800,000	6.8	90.1
6	Composite	6,500,000	6.5	96.6
7	Rollup door	1,800,000	1.8	98.4
8	Concrete Cornice	1,600,000	1.6	100
	Total	100,000,000		

A second Pareto analysis is performed on each of the works chosen in the previous study. The sub-works in the glass sunshade, curtain wall, door and window, and bio-wood sectors are subjected to analysis. The second Pareto analysis's summary is presented in Table 2.

Table 2. Sub Work Pareto Analysis

No	Detail of Work	Budget (MMK)	Percentage Cost	Cumulative Percentage
	Door and Window			
1	Slide window	16,500,000	53.22	53.22
2	Swing window	12,000,000	38.70	91.93
3	Entrance Door	2,500,000	8.06	100
		31,000,000	100	
	Curtain Wall			
1	Fixed Wall	25,000,000	77.39	77.39
2	hophung window	7,300,000	22.60	100
		32,300,000	100	
	Biowood			
1	Wall Area	10,000,000	83.33	83.33
2	Boundary	2,000,000	16.66	100
		12,000,000	100	
	Glass Sunshade			
1	Front area	6,000,000	75	75
2	Side area	2,000,000	25	100

4.2 Function analysing phase

The goal of each Façade work component is looked at in order to evaluate which work has the most potential to increase the project's overall cost. Each task must undergo a cost-to-worth analysis to determine which one has the greatest potential to raise the project's total cost. If C/W is larger than 1, value engineering can be applied to assess the work item. The C/W results for each piece of work are displayed in Table 3. The four activities that were previously determined using the Pareto analysis have a C/W result that is larger than 1 as shown in Table 3. This suggests that those works that are amenable to value engineering study.

Table 3. Cost to Worth Ratio Result

No	Scope of work	C/W ratio
1	Door and Window	1.88
2	Curtain wall	1.27
3	BioWood	1.19
4	Glass Sunshade	1.34

4.3 Creativity Phase
In this stage, a few substitute concepts for the original design are suggested. When choosing a replacement material, take into account the following characteristics:

- Initial Cost
- Maintenance Cost
- Quality.

4.6 Evaluation Phase
The different ideas will next be subjected to life cycle cost (LCC) analyses to ascertain their relative financial worth given an expected interest rate and the lifespan of the building. LCC evaluations measure the total cost of the project during its lifetime and the amount of money saved due to the alternative material. A 40-year life expectancy for the hospital structure was estimated in order to finish the LCC analysis. The proportion of cost savings from the LCC analysis for each alternative material is shown in Table 4.

Table 4. Percentage of Cost Saved from Alternative Materials

No	Detail of Work	Cost Saving		
		Alternative 1	Alternative 2	Alternative 3
	Door and Window Work			
1	Slide Window	3	7.6	5
2	Swing Window	-2	1.45	3.6
	Curtain Wall			
1	Fixed Wall	4	11	8
	Biowood			
1	Wall Area	5	4.3	6.7
	Glass Sunshade			
1	Front Area	3.2	-1	6

4.4 Decision analysing phase
The process of analyzing severalpossibilitiesin order to pick those with the highest potential to lower project costs. The original design will be replaced with the alternative material that, based on the life cycle cost analysis, results in the largest cost reduction. Which materials, in terms of a percentage, save the most money is shown in Table 4.

4.5 Decision making phase
A decision is made on which alternative concepts would replace the original design at a reduced cost after undertaking numerous studies. The option with the highest potential for cost reduction was chosen. The results of the chosen choice are described in Table 5.

Table 5. Chosen Alternative Material

No	Detail of Work	Alternative Chosen
	Door and Window Work	
1	Slide Window	Alternative 2
2	Swing Window	Alternative 3
	Curtain Wall	
1	Fixed Wall	Alternative 2
	Biowood	
1	Wall Area	Alternative 3
	Glass Sunshade	
1	Front Area	Alternative 3

5. CONCLUSION

The result of the VE analysis saved 7.6 percent of the specified items of work. This reduces the price of the façade work by up to 7,600,000 MMK. The alternate material selected to replace the original design is the one that contributes most to decreasing the cost of each individual piece of work. In this research, the researcher references the other comparative studies, methodology of other studies and then construct the research frame work and analysis on the six stories hospital building façade project. Although the analysis results are showing the benefit of value engineering in the façade work, next researchers should analysis on more project for more reliability of the result for the further study.

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Conflict of Interest
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in the public, commercial, or not-for-profit sectors that could have influenced the outcome of this work.

Data Availability Statement

The datasets analyzed during the current study are available from the corresponding author on reasonable request. The data has been de-identified to protect the privacy of the participants. Further details about the data collection process and methodology can be obtained by contacting taung@lincoln.edu.my

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