



## Value Engineering Evaluation of Sidoarjo's Class I Trosobo Weighbridge Revitalization Project

Akhiriansyah<sup>1\*</sup>, Budi Witjaksana<sup>2</sup>, Erni Puspanantasari Putri<sup>3</sup>  
Civil Engineering Master's Study Program, Faculty of Engineering Universitas  
17 Agustus 1945 Surabaya, Indonesia  
**Corresponding Author:** Akhiriansyah, [akhiriansyahone@gmail.com](mailto:akhiriansyahone@gmail.com)

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### ABSTRACT

Weighbridges are public infrastructure used to monitor, collect data, and enforce laws pertaining to freight trucks on district, provincial, and national routes. A Detailed Engineering Design (DED) for the restoration of the Class I Trosobo Weighbridge in Sidoarjo was produced in 2024 by the East Java Class II Land Transportation Management Agency (BPTD). The National Road Management Agency (BPJN) eventually carried out the renovation. The BPJN performed a re-DED because of financial inefficiencies. In order to achieve a cost advantage or lower than the previously projected price, volume analysis was employed in the architectural work to examine tasks that might be carried out more effectively. Savings of Rp 559,302,447.53 million, or 7.07% of the original rejuvenation cost, were obtained by volume analysis.

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## **INTRODUCTION**

A building is a man-made structure consisting of walls and a roof, permanently erected in a specific location and used as a supporting infrastructure for daily human activities. Thorough planning is required to create a good building. Structural and other planning are necessary to ensure a sturdy, economical, and comfortable building, especially for buildings used as public facilities or public spaces, such as weighbridges. Weighbridges should be designed to ensure the public feels safe and comfortable while in the area. Furthermore, the design of buildings for public facilities must also comply with established operational standards and procedures.

According to Minister of Transportation Regulation Number 60 of 2019 concerning the Implementation of Motorized Freight Transportation on Roads, a weighbridge is a facility used by weighbridges to measure the weight of vehicles and their loads, which functions to monitor and ensure vehicles do not exceed the specified load limits. Weighbridge structures must be sturdy and have adequate facilities to ensure public safety and comfort.

One work item that can still be cost-effective is architectural work. Several factors contribute to the high cost of architectural work, including materials and technology.

The use of expensive materials can increase the cost of an architectural project. Good-quality materials will ensure a building is durable and safe for use. However, the selection of building materials must also be tailored to the needs. Building materials that are easy to maintain and do not require complicated or expensive maintenance can help save on building maintenance costs in the long term. Furthermore, the selection of materials must also consider aesthetic value to create an attractive appearance that matches the desired architectural style, thus adding value to the building's aesthetic value. Furthermore, the project duration and labor also affect the cost of architectural work. The longer the time required, the greater the costs, including the costs of materials, labor, and supervision.

With the goal of achieving better or lower costs than the planned price for work items, value engineering is necessary. Several factors contribute to the high cost of architectural work, including materials and technology. The use of expensive materials can increase the cost of an architectural project. For example, using more expensive materials such as marble, granite, or high-quality glass can significantly increase project costs. There are many material options available. Good-quality materials will ensure a building is durable and safe for use. However, the choice of building materials must also be tailored to the needs. Building materials that are easy to maintain and do not require complicated or expensive maintenance can help save on building maintenance costs in the long term. Furthermore, the choice of materials must also consider aesthetic value to create an attractive appearance that matches the desired architectural style, thus adding value to the building's aesthetic value. Furthermore, the project duration and labor also influence the cost of architectural work. The longer the time required, the greater the costs incurred, including the costs materials, labor, and

supervision. Likewise, the more and better-qualified the labor required, the greater the costs.

On the other hand, architectural work is also important because buildings serve not only as residences, but also as places to work, shop, study, worship, and hold various public events. Architectural work must ensure that the building has a clear function and is designed to be comfortable for its occupants. Safety and health systems must also be taken into account, such as fire prevention systems, air circulation, lighting systems, and wastewater treatment systems. The impact on the surrounding environment must also be taken into account to maintain the sustainability and balance of our environment. Furthermore, architectural work must determine the exterior and interior appearance of the building, which can influence its image and aesthetics.

In light of the above, the researcher intends to conduct research using value engineering. Value engineering is a creative and planned approach aimed at identifying and eliminating unnecessary costs. Value engineering is used to identify alternatives or ideas aimed at achieving better or lower costs than previously planned prices, within functional limitations and work quality. Value engineering in architectural building work is conducted to optimize the value of a building or architectural project by considering factors such as quality, cost, function, aesthetics, and safety.

Value engineering has several stages, which aim to generate ideas for alternative designs that can fulfill the basic function of the selected work item. The third stage is the analysis stage, which determines the feasibility of an alternative and the best of the available alternatives. The fourth stage is the recommendation or presentation stage, which is the final stage in the value engineering work plan. The purpose is to provide a report on all previous stages to determine whether the selected design is feasible and appropriate for implementation.

It is hoped that using value engineering will improve efficiency in the RAB DED for the Class I Trosobo Weighbridge in Sidoarjo, resulting in an efficient building design that still complies with applicable regulations and standards.

## **THEORETICAL REVIEW**

Value engineering (VE) has been increasingly applied in infrastructure projects to enhance functionality while minimizing costs, making it a relevant approach for evaluating the Class I Trosobo Weighbridge revitalization project in Sidoarjo. The literature defines VE as a systematic method that analyzes project functions to identify cost-saving opportunities without compromising quality, safety, or performance. Studies on transportation and logistics infrastructure show that VE workshops—where multidisciplinary teams explore alternative materials, design modifications, and process improvements—can lead to significant reductions in construction and operational costs, as well as improved service delivery. Research also highlights that critical phases of VE, such as information gathering, function analysis, creative idea generation, and evaluation of alternatives, are essential for uncovering innovative solutions that align with stakeholder needs and regulatory requirements. Furthermore,

empirical evidence suggests that VE contributes to better resource allocation, accelerated project schedules, and enhanced long-term maintainability, particularly when combined with life-cycle cost analysis. In the context of weighbridge facilities, VE can optimize elements such as weighing technology integration, structural layouts, and traffic flow management to improve accuracy, throughput, and user satisfaction. Overall, the literature underscores that applying value engineering to the Trosobo Weighbridge revitalization can support cost-effective enhancements while maintaining operational integrity and strategic value.

## **METHODOLOGY**

### ***Value Engineering Phases***

The specific characteristic of the Value Engineering concept is the systematic analysis conducted from the beginning of the analysis until an accountable final result is obtained. This systematic approach consists of interrelated phases. These phases are known as the Value Engineering Job Plan. The phases are:

#### *Information Phase*

This phase involves excavating and collecting the necessary information and data based on the questions in the value engineering job plan. This is followed by identifying high-cost work items. The required data is project data containing general project information, project building functions, and design constraints. Project data is needed to obtain basic information about a project. Project information is obtained by directly requesting it from the consultant or executor handling the project or the project owner. Several basic principles carried out in the information phase are the breakdown cost model and conducting cost analysis, percentage analysis, analysis per work item, unit price analysis, and work quantity analysis.

#### *Breakdown Cost Model*

By using the breakdown cost model to sort work items from the highest cost to the lowest cost and then presenting them cumulatively.

#### *Total Cost Comparison Analysis*

Alfred Marshall (late 1800s): This English economist formalized and popularized the basic concepts put forward by Deputi in his work, *Principles of Economics* (1980), providing a stronger theoretical foundation for economic analysis.

Total Cost Comparison = RAB1 - RAB2 (cost difference)

This total cost comparison analysis aims, among other things, to:

- 1) Review and evaluate cost elements separately.
- 2) Compare the profit or cost of a project to determine a fair price or project feasibility.

It also serves the functions of:

- 1) Presenting data horizontally and comparing it, both in Rupiah currency and in units.

- 2) Showing the difference or variance in the price or cost of a project.

#### *Percentage Difference Analysis*

Percentage difference analysis research on project costs is a study conducted to analyze and calculate the difference (variance) between the planned cost (Rencana Anggaran Biaya/RAB) and the actual or real cost incurred during the project execution, which is then expressed as a percentage.

U.S. Department of Defense (DoD): EVM (Earned Value Management) originated from the DoD's efforts in the 1960s to measure the performance of defense projects more effectively. They introduced criteria that became the basis for modern EVM, later known as Cost/Schedule Control Systems Criteria (C/SCSC).

$$(RAB1 - RAB2) \times RAB2 \times 100\% = \text{Percentage Cost Difference}$$

The main objectives of this research include:

- 1) Budget Performance Evaluation: To assess how effective the initial budget planning was and to identify potential errors in cost estimation.
- 2) Comparison of Calculation Methods: This research often compares the RAB calculated using standard methods (such as SNI) with calculations used by contractors on site to determine which method is more accurate.
- 3) Identification of Causal Factors: To determine the factors that cause cost variances, such as rising material prices, design changes, errors in work volume calculations, or inefficient project management.
- 4) Future Decision Making: The results of this research can be used as valuable input for stakeholders (owner, contractor, consultant) for improvements in planning and execution of subsequent projects.

#### *Analysis per Work Item*

Frederick W. Taylor: Known as the father of scientific management, his work in the late 19th and early 20th centuries involved time and motion studies to optimize work processes and set efficient time standards for each task, which indirectly underlies the calculation of labor needs per work item.

Analysis per work item refers to the process of in-depth evaluation and detailing of every individual component or task within a project, business process, or cost structure.

The main objective of this analysis is to specifically understand:

- 1) Scope and Tasks: Exactly what needs to be done in that task.
- 2) Resources: Labor, materials, equipment, or tools required.
- 3) Time: Estimated duration required to complete it.
- 4) Cost/Budget: Estimated cost associated with the resources used.
- 5) Dependencies: The relationship of the task with other tasks in the project.
- 6) Risk: Potential problems or challenges that may arise during execution.

In a different context, "analysis per work item" can refer to specific things such as:

1) In Project Management: This is part of developing the Work Breakdown Structure (WBS) to ensure every work package can be measured, managed, and tracked.

2) In Cost/Budget Estimation: This is the process of calculating the unit cost (such as Work Unit Price Analysis/AHSP in construction) for each type of work, which is then used to compile the total project budget.

3) In Performance/HR Management: This can mean analyzing specific tasks that form someone's job description for performance evaluation or salary setting purposes.

In short, this is a detailed approach that breaks down the big picture into smaller, manageable parts for more effective planning, execution, and control.

### *Work Quantity Analysis*

Work quantity analysis is the process of calculating and measuring the quantity (volume) of every required construction work item, including materials, labor, and equipment. The goal is to obtain accurate data on resource needs to compile an effective budget (RAB) and project schedule.

Details of work quantity analysis:

1) Volume Calculation: Involves calculating the amount of material and labor required for each type of work based on detailed drawings. This is the basis for compiling the Bill of Quantity (RAB).

2) Resource Needs Identification: Through this analysis, it can be specifically determined what materials are needed, the amount of labor, and what equipment is required to complete the work.

3) Basis for Cost and Time Planning: The results of the quantity analysis become the basis for determining the total project cost and the duration of project completion. The greater the work quantity, the longer the required duration, which can be calculated based on work productivity.

4) Supporting Documents: The results of this quantity analysis are usually outlined in a document called the Bill of Quantities (BoQ). This document is an important guide for the contractor in preparing price bids and managing the project efficiently.

### *Creative Phase*

In this phase, innovation and creativity are used to process cost elements that have the potential to cause cost loss while still adhering to the principle of not reducing the performance, quality, benefits, function, and aesthetics of a selected work element in the value engineering concept. This phase is the most difficult to implement, where several alternatives and innovations are created to be considered in decision-making. The creative process can be obtained from basic knowledge, experience, the latest information, and so on. If several alternatives from the creative process have been determined, further analysis can be carried out. These alternatives can be reviewed from various aspects, namely:

#### *Material*

With the advancement of technology, materials that have the same function can be produced with almost the same quality but at different costs.

Merely because of a different brand or license, the price of the material becomes different. Thus, the selection of material alternatives can be done in the value engineering analysis.

#### *Execution Method*

In carrying out a job, there is certainly a respective way or method. In the past, the way to complete a job relied only on human labor with simple tools, so the completion time required a long duration. Along with technological advances, more sophisticated tools have emerged to help complete the work. Therefore, in value engineering analysis, the execution method can be designed with several alternatives, because the shorter the time required to complete the work with optimal equipment, the smaller the cost incurred.

#### *Execution Time*

Every job in a project has an execution schedule in the time schedule planning. For some work items with a fixed work weight, the execution time can be reduced. Many ways are done to achieve this, including adding the number of workers and others. Thus, the alternative of reducing execution time can be used as an alternative, as it will affect the budget cost.

#### *Analysis Phase*

This phase will conduct an analysis of the supporting tools that emerge. The analysis includes Life Cycle Cost (LCC) analysis and profit and loss analysis.

##### a. Profit and Loss Analysis

In this analysis, the ideas obtained in the creative phase will have their pros and cons compiled. Some criteria that can be used to filter ideas are:

- \* Cost benefits
- \* Whether the proposed idea meets the given functional requirements
- \* Whether the new alternative is reliable
- \* Whether excessive redesign will occur to implement the idea
- \* Whether there is an improvement to the original design
- \* Whether the proposed alternative has ever been used
- \* Whether the alternative affects the building's aesthetics

After the pros and cons of each idea are recorded, a weight is then given to each alternative.

#### *Project Life Cycle Cost (LCC) Analysis*

The life cycle of a project consists of six major stages: conception and feasibility study, engineering and design, procurement, construction, start-up and implementation, and operation or use. It is further stated that accurate cost measurement is one of the most important requirements for a successful value engineering concept.

Cost analysis from the owner's perspective must consider capital, future operating, and maintenance costs to achieve the maximum value from a minimum overall investment. Life cycle cost is commonly used as an aid in economic analysis to find various alternative possibilities in decision-making and

describes the present and future value of a project over its useful life, taking into account interrelated economic and monetary factors.

Broadly speaking, life cycle cost is the total cost of ownership and operation of a facility, depicting the present and future costs over the project's lifespan. In project life cycle cost analysis, alternatives are analyzed against the project life cycle cost.

According to Fuller (2006), Life Cycle Cost is a method for assessing the total cost of facility ownership, accounting for all costs of acquiring, owning, and disposing of a building or building system. Another definition of Life Cycle Cost according to Fuller and Petersen (1996) is an economic method for evaluating a project based on all costs incurred, from the cost of ownership, operation, maintenance, to the disposal or removal of the project, which is considered potentially very important in decision-making. Meanwhile, according to Glucha and Baumann (2003), Life Cycle Cost is the total discounted cost of a product, process, or activity over its lifespan. Thus, it can be concluded that Life Cycle Cost is the overall cost of a construction, starting from the initial cost, usage cost, and maintenance cost, up to the demolition cost of that construction.

Generally, the calculation of life cycle cost involves several cost components, such as initial cost, operational cost, and demolition cost. Fuller (2006) mentions several associated costs such as the cost of acquisition, operation, maintenance, and replacement or demolition of the building or building system.

The costs generally associated with a building construction are as follows:

1) Initial Cost

The initial cost is the cost that covers the planning cost of the construction project, the supervision cost, and the construction cost of the project. In other words, the initial cost is the overall cost of constructing a building from start to handover of the construction work.

2) Operational Cost

Operational cost is the cost incurred during the operation or use of the construction. This includes the cost of employee salaries, electricity, and water.

3) Maintenance and Upkeep Cost

Maintenance and upkeep cost is the cost incurred for the process of maintaining and caring for a construction building so that it remains functional during the service life of the building. In this research, the service life of the terminal building is assumed to be 50 years.

4) Material Replacement Cost

Material replacement cost is the cost incurred for replacing materials of a construction when they have reached the planned service life. Demolition is assumed to be carried out at the end of the building's service life, which is in the 50th year.

After identifying all associated costs by year and amount, they are then converted into the present value, and then these costs are summed to obtain the life cycle cost.

$LCC = \text{Initial Cost} + \text{Operational Cost} + \text{Maintenance Cost} + \text{Material Replacement Cost}$  (2.2)

Life Cycle Cost is a method that, at least in theory, has the potential to evaluate construction work. Of course, evaluating a project based only on the initial construction cost is insufficient.

### *Recommendation Phase*

The recommendation phase is the final stage of the value engineering job plan. In this stage, the task is to provide a recommendation or the best analysis result to be selected or used.

Each phase has its own objective and a key question that must be answered as a tool. The work stages must proceed step by step, but it is possible to return to the previous stage if necessary.

Value Engineering (VE) is a systematic and structured multidisciplinary decision-making process. It conducts a functional analysis to achieve the best value for a project by defining the necessary functions to achieve the desired value goal and providing those functions at the optimum cost, consistent with the required quality and performance (Berawi, 2013).

As a functional identification, the approach taken by Value Engineering is to differentiate between the understanding of value and cost because:

The measure of price or cost is determined by the substance of the goods, namely the cost of the components that form the goods, while value is determined by the usefulness function of the goods.

Cost is how much material expenditure has been made to obtain the goods, while the measure of value tends to be subjective and largely depends on how far the owner can utilize it.

The Value Engineering method was developed to provide a systematic way of managing value and increasing innovation efforts to give a competitive advantage to a product. Value engineering focuses on a value to achieve an optimum balance between time, cost, and quality. This concept considers the relationship between value, function, and cost in a broader perspective to create greater value for the specified project (Berawi, 2013).

### *Bill of Quantity (RAB)*

Bill of Quantity (RAB) is a series of steps in the construction planning process; the budget planning for a building is planned before the work begins. To calculate the building budget, a detailed calculation analysis needs to be made regarding the amount of material used and labor wages. To make it easier, the volume of each type of work needs to be calculated. From there, the total price amount for material and wages for each related type of work is compiled (Zainal, 2005).

In every construction activity, resources are needed that are suitable for the project being executed, and we know that every resource requires a cost.

Bill of Quantity (RAB), or more often called the Bill of Quantity, is an estimated value of a project that is an estimate and will not be the same as another project at a different time.

According to Ervianto (2002), there are several factors that influence the creation of the Bill of Quantity:

3. Labor productivity
4. Material availability
5. Weather conditions at the project location
6. Type of project contract
7. Issues with the desired quality
8. Control system
9. Management capability

Project cost estimation plays a very important role in the execution of a project, not least in building construction projects. In the initial stage, project cost estimation is used as a reference to determine the size of the cost needed for project construction, which then has a very broad function, namely for the planning and control of resources used, such as human resources, materials, workers, up to the duration or time required.

In the construction of a project, there are 2 types of costs required for a project to run. Namely fixed capital and working capital.

#### *Fixed Capital*

Is the capital required to build the installation or product of the desired project, in this case, a building or construction that is carried out according to the plans that have been made.

#### *Working Capital*

Is the capital used to cover needs at the beginning of the execution process, and must not depend on fixed capital because it can reduce the quality of the planned product. Working capital is usually the capital provided for the purchase of supporting resources that must be present, such as K3 (Occupational Safety and Health), spare parts for equipment used, initial inventory, and initial labor wages.

In every planning, there are several steps in the execution, and the same goes for creating the Bill of Quantity (RAB). The steps in planning the RAB are as follows:

#### *Creating Work Items*

Namely determining what jobs will be carried out in a construction project.

#### *Calculating Work Volume*

By calculating the volume of work based on the work items that have been determined first.

#### *Creating a List of Unit Prices for Labor and Materials*

In the form of a list of material and wage prices adjusted to the location where the project is carried out.

*Creating a Work Analysis per Work Item*

Work analysis is the calculation of the material, labor, and equipment needs to carry out the work; work analysis can refer to SNI (Indonesian National Standard).

*Creating the Bill of Quantity (RAB)*

The Bill of Quantity is created from the analysis we make based on the result of multiplying the work item by the volume and the result of the analysis of each work item.

*Creating the RAB Recapitulation*

In the form of a summary of every work item, which will then determine the value of a project or construction activity.

**RESULTS AND DISCUSSION**

The recommendation stage is the final stage of the value engineering work plan. This stage provides recommendations or the best analysis results to be selected or used. The results of all analyses determine the best alternative, which will be used as the final value engineering result.

Alternative 1:

Gardening work (Landfilling and planting mini elephant grass)

Cost Savings Construction Cost Savings:

Rp. 576,994,272 - Rp. 735,349,442 = -

Rp. 158,355,170

Total life cycle cost savings:

Rp. 1,149,073,358 - Rp. 1,477,016,858 = -Rp. 327,943,500

Or -2.7%

Work Item: Exterior Facade

Existing Aluminum Composite Panel (ACP) Wall Cladding

Selected Alternative: Alternative 1:

Glass Reinforced Concrete (GRC) Wall Cladding

Cost Savings: Construction Cost Savings:

Rp1,999,985,847 - Rp562,824,480 =

Rp1,437,161,367

Total Life Cycle Cost Savings:

Rp3,982,934,607 - Rp1,130,484,630 =

Rp2,852,449,977

Or 30.78%

Work Item: Floor

Existing 60x60 polished homogeneous Roman tile flooring

Selected Alternative: Alternative 1:

Epoxy flooring

Cost Savings Construction Cost Savings:

Rp964,481,871 - Rp525,202,500 =

Rp439,279,371  
Total life cycle cost savings:  
Rp1,920,747,705 - Rp1,045,931,009 =  
Rp874,816,696  
Or 35.57%

## **CONCLUSION AND RECOMMENDATION**

Based on the analysis of the application of value engineering methods to the revitalization of the Class I Trosobo Weighbridge in Sidoarjo, the following results were obtained:

- 1) The value engineering results identified three work items that could be analyzed: yard and parking work, exterior facade work, and flooring work. The recommended design alternative for the yard and parking work is to create a garden consisting of planting media, mini elephant grass, and trees with a diameter of less than 15 cm. The recommended design for the exterior facade work is to replace Aluminum Composite Panels (ACP) with Glass Reinforced Concrete (GRC). The recommended design for the flooring work is to replace polished 60x60 Roman homogeneous tiles with epoxy flooring.
- 2) After applying value engineering to the architectural work of the Trosobo Class I Weighbridge revitalization project in Sidoarjo, the final cost savings were Rp1,718,085,568, or 8% of the initial architectural project cost of Rp21,482,530,792. After value engineering, the total architectural project cost was Rp19,764,445,224.

Based on the analysis and preparation of the final assignment conducted by the author, several recommendations are more knowledge and insight are needed regarding alternative designs and materials.

## **FURTHER STUDY**

Further research is needed to analyze the impact of material replacement on architectural work.

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