Application of Value Engineering in Retention Ponds Construction: A case study in ITB Cirebon

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Abstract. Construction projects in various countries have suffered irreparable losses after completion. It's possible that it's due to construction process complications or another phenomenon. Before moving on with the design or construction stages of a project, the owner must provide a cost estimate. The cost often becomes a problem because amount of the cost is limited to realize a construction project. The present study revealed that Value Engineering can be utilized during the project life cycle as a helpful instrument from the beginning of studies to the end of construction. This method can be delineating alternatives and to suggest choices based on the necessity of the function based on cost-worth relationship.Value engineering (VE) is a method of examining the function of goods and services in order to acquire the user's desired functionalities at the lowest overall cost while maintaining high performance quality. This study contributes to providing empirical evidence of the advantages of implementation VE in determine construction methods that can be effective to reduce unnecessary costs especially at Retention Ponds Construction Stage in Construction of ITB Cirebon-Indonesia.

1. Introduction

The construction of the ITB Cirebon is one of ITB's commitments in the development of multicampus. This is a form of increasing ITB's role in developing future research and the quality of human resources. The area is located in Arjawinangun District, Cirebon Regency. Built on an area of 30 hectares, it is prepared for seven study programs, including Industrial Engineering, Crafts, Urban and Regional Planning, Geophysical Engineering, Mining Engineering, Petroleum Engineering, Oceanography Engineering. One of the developments carried out is to build a Retention Pond which is used to regulate and accommodate the supply of rainwater and to controlled the water before it flowing into the river to prevent flooding.

Construction phase is the most dynamic phase of all project life cycle. Problems on the construction phase going on for many things, but the cause that often arises is the difference in the implementation of the planning of the field. On this study case there is a difference in conditions between the design and the actual. After the Mutual Check-0 (MC-0) it is found that volume of excavation soil does not meet the volume to fill the embankment and form the construction of the retention pond. Because of that it is necessary to bring in soil materials from outside the ITB area to fill the embankment area. However, to bring in soil material from outside it will increase the construction cost, so an alternative must be made to keep the retention ponds built and can be function properly. The cost savings for the Retention Pond construction at the ITB Cirebon campus was carried out using value engineering techniques. Value engineering is a management technique that uses a systematic approach to find a functional balance between the cost, reliability and performance of a product or project.

The retention ponds project is very important to be built considering the geological and weather conditions in the construction area. Therefore, the constructability of retention ponds needs to be assessed based on facts obtained in the field. To meet constructability requirement, it can be done by optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives (Wong et al., 2006). The VE implementation is to avoid unjustifiable error or oversight by the design team. So that the retention ponds can still be built by conducting an assessment based on construction documents with an assessment instrument that can be accounted for and didn't reduce the function of the building in accordance with project constructability.

2. Problem

Value Engineering (VE) is the systematic application of recognized techniques by a multi-disciplined team which identified the function or services (Sharma and Belokar, 2012). In this case study VE is used to analyse constructability of Retention Pond based on design document and field observation for later scoring. VE analysis is implemented on MC-0 phase based on construction document right before the contractor start to work (Figure 1).

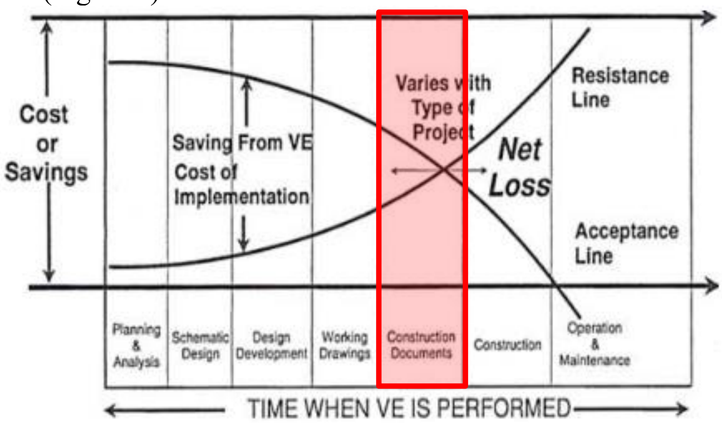

Figure 1. Life Cycle Costing

In a VE study, numerous components must be examined because VE is a complex. Furthermore, VE's potential and actual applications in the construction industry are numerous and varied. The VE tool used in this research is Value Standard and body of knowledge by SAVE International.

3. Application of Value Engineering Methodology

Time constraint, habitual thinking, a lack of communication and coordination processes, inadequate standards or specifications, old technology, a reluctance to seek guidance, and poor interpersonal are contributed to low-value items that need to be processed.

Unnecessary costs are inevitable during the project phase. Therefore, the VE of this branch focuses on the evaluation of alternative materials, construction methods, assembly techniques, and analysis of life cycle costs. VE was then developed to eliminate and improve these factors and achieve efficiency and efficacy through the following three approaches by (Sesmiwati,2016):

- Cost reduction. This procedure is performed by maintaining the required functionality and quality of the product while reducing costs.
- Enhanced functionality. In this way, you improve the functionality and quality your product requires while maintaining cost.
- Hybrid. This technique uses both cost reduction and enhancement techniques to improve product functionality and quality while reducing costs.

(Abdel-Raheem, 2018) said that there are some VE tools use by different institution, more tools have been developed to aid the implementation of VE principles and decision making in the workshops as the use and implementation of VE has risen dramatically over the previous decade. These tools are designed to find ways to increase project value while lowering expenses. Methodology study of this research shown on the following flowchart.

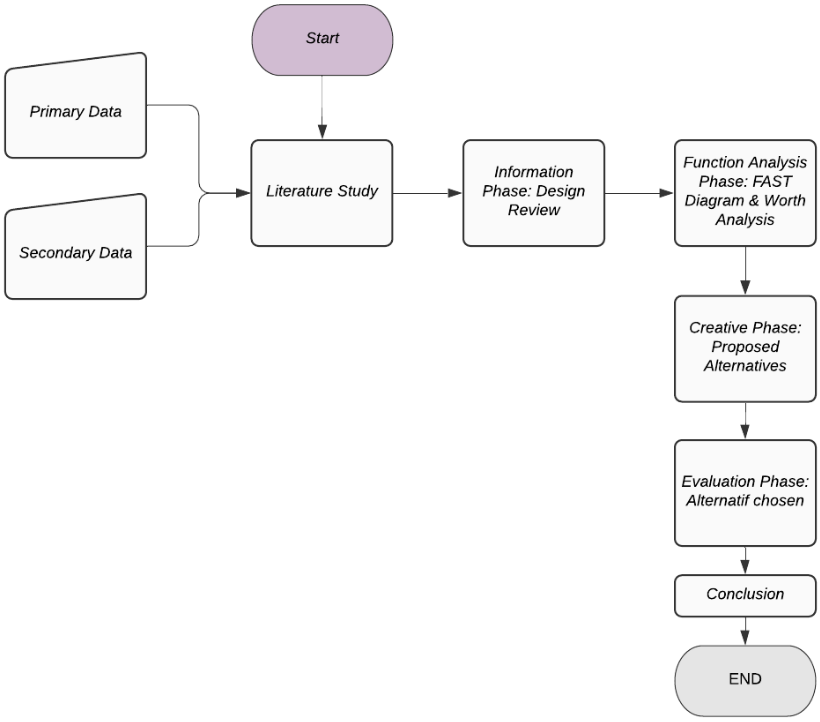

Figure 1. Methodology Study of The Research

3.1. FAST (Function Analysis System Technique)

FAST diagrams employ graphical tools to depict the logical linkages between project functions based on the "How" and "Why" questions. It becomes easier to identify and clarify all of the relevant project functions by grouping the functions in this manner. It is easier for groups to communicate and identify alternatives to the functions put out when the functions are made explicit. Furthermore, it becomes clearer how functions are linked and, as a result, how a single solution can solve several problems.

3.2. Benefit-cost analysis (BCA) or function-cost analysis (FCA)

Typically, multiple alternatives that have the potential to create value and reduce costs are given in a VE. The BCA and FCA are approaches for comparing offered alternatives in a systematic manner. These strategies can be used in two simple steps:

3.2.1. Determine the project's primary and secondary functions. Although innovation in attaining these duties is welcomed, the basic functions are the aspects of the project that must be completed. Secondary functions, on the other hand, are bonuses; these are the qualities that attract customers.

3.2.2. Create matrixes that compare the various options. They are also the areas where the highest innovation and cost-cutting opportunities exist. The advantages (cost savings) and disadvantages (costs) of implementing the alternatives are then determined. A greater-than-one benefit-to-cost (B/C) ratio implies that the benefits of implementing the alternative outweigh the cost of adoption. Conducting BCA and FCA results in the selection of an alternative that both improves performance or solves an issue, with better or equivalent results to the original plan, while also lowering costs compared to the original plan.

3.3. Theory of inventive problem solving (TRIZ)
Using TRIZ approaches to boost human inventiveness is a viable option. This is accomplished by first identifying the issues and then considering the best possible remedies. A special emphasis is placed on how additional functionality might be obtained at a lower cost.

3.4. Value Standard and body of knowledge by SAVE International
This Standard will help managers, value program managers, practitioners, and trainees apply value methodology consistently and consistently in their businesses. It might also help people who buy value methodology services write proposal requests that assure they get thorough and useful value methodology services.

3.4.1. Information Phase. The team assesses and specifies the project's current state, as well as the study's objectives.

3.4.2. Function Analysis Phase. The project functions are defined by the team using a two-word active verb/measurable noun context. The team examines and evaluates these functions to see which ones need to be improved, eliminated, or added in order to satisfy the project's objectives.

3.4.3. Creative Phase. The team employs creative techniques to identify other ways to perform the project’s function(s).

3.4.4. Evaluation Phase. While providing the project's function(s) and considering performance criteria and resource restrictions, the team uses a systematic review process to pick those ideas that have the potential for value increase.

3.4.5. Development Phase. The team turns the chosen ideas into alternatives (or proposals) with enough documentation to allow decision-makers to decide whether or not to implement the alternative.

3.4.6. Presentation Phase. The team leader creates a report and/or presentation that documents and communicates the adequacy of the team's alternative(s) and the accompanying opportunity for value improvement.

4. Result

4.1. Information phase
After the Mutual Check-0 (MC-0) it is found that volume of excavation soil does not meet the volume to fill the embankment and form the construction of the Retention Pond. Because of that it is necessary to bring in soil materials from outside the ITB area to fill the embankment area. The result of MC-0 calculation can be seen on the following table.

Table 1. Bill of Quantities Shortlist Based on Contract and MC-0

No	Retention Pond Construction Works	CONTRACT		MC-0	
		Volume	Unit	Volume	Unit
	Retention Pond Build 1				
1	Excavation works	6.334,14	m3	4.863,90	m3
2	Landfilling works using excavation soil	5.067,32	m3	3.891,12	m3
3	Soil dumping works	1.266,83	m3	972,78	m3
4	Sand and stone filling t=25 cm CBR >40%	1.865,91	m3	2.016,20	m3
5	Landfilling works using chosen material t=15 cm	827,93	m3	827,93	m3
6	Geomembrane layer t=1mm	5.519,50	m2	5.519,50	m2
7	Geotextile non-woven layer	2.928,55	m2	2.928,55	m2
8	Rip rap works	916,46	m3	828,50	m3
	Retention Pond Build 2				
1	Excavation works	10.496,82	m3	5.335,60	m3
2	Landfilling works using excavation soil	8.397,46	m3	4.268,48	m3
3	Soil dumping works	2.099,36	m3	1.067,12	m3
4	Sand and stone filling t=25 cm CBR >40%	2.178,42	m3	2.374,63	m3
5	Landfilling works using chosen material t=15 cm	946,12	m3	946,12	m3
6	Geomembrane layer t=1mm	6.307,44	m2	6.307,44	m2
7	Geotextile non-woven layer	3.752,90	m2	3.752,90	m2
8	Rip rap works	1.127,99	m3	1.011,75	m3

As we can see on contract Bill of Quantities there is no landfilling works, but after the owner, consultant, and contractor do benchmarking the result of MC-0 appear. It was found that the existing land elevation was not in accordance with the design drawings. The existing ground elevation is one meter below the design elevation.

Other information besides the needs of soil material addition is the geomembrane and geotextile. On the planning, the designers use the geomembrane material to keep the water level at Retention Pond controlled and not directly absorbed into the soil. The geotextile is used to keep the slopes at is shapes and to be the media of *riprap* works.

4.2. Function Analysis Phase

The function of the Retention Pond is to regulate and accommodate the supply of rainwater and to controlled the water before it flowing into the river to prevent flooding. So, at this phase the authors made a shortlist from the works item see which ones need to be improved, eliminated, or added to make Retention Pond work as it functions.

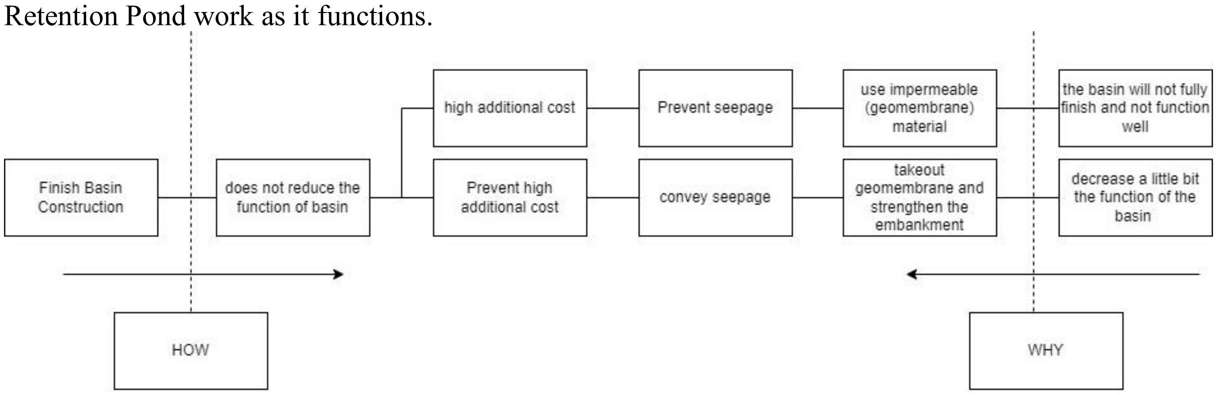

Figure 2. FAST Diagram

The shortlist can be seen on the following table.

Table 2. Function Analysis: Worth Item Analysis

No	Retention Pond Construction Works	Function Analysis Review
	Retention Pond Build 1	
1	Landfilling works using chosen material	Need to be added
2	Geomembrane layer t=1mm	Need to be eliminated
3	Geotextile non-woven layer	Need to be eliminated
4	Rip rap works	Need to be improved
	Retention Pond Build 2	
1	Excavation works	Need to be recalculated
2	Landfilling works using excavation soil	Need to be recalculated
3	Landfilling works using chosen material t=15 cm	Need to be recalculated
4	Geomembrane layer t=1mm	Need to be eliminated
5	Geotextile non-woven layer	Need to be eliminated
6	Rip rap works	Need to be improved

4.3. Creative Phase

The Retention Pond is construct to accommodate the supply of rainwater and to controlled the water before it flowing into the river to prevent flooding. Based on secondary data it is known that existing soil characteristic is silt and saturated. Based on the shortlist from function analysis phase the authors continue to creative phase to see which one need to eliminate or to be improved so it can be work in accordance to function, cost and time. After the creative phase the cost is reduced to Rp 1.453.807.491 or 24,7% from the initial contract. It is also giving an impact to construction time; the initial prediction time is 14 months but it is become to 15 months according to added works.

Table 3. Creative Phase Analysis: Cost and Time Analysis

No	Retention Pond Construction Works	Cost		Schedule Prediction	
		Contract	Creative Phase	Contract	Creative Phase
1	Retention Pond Build 1	Rp 1.431.511.033	Rp 824.967.550	14 months	15 months
2	Retention Pond Build 2	Rp 1.814.058.333	Rp 966.794.325	14 months	15 months

4.4. Evaluation Phase

The systematic review process in decision matrix table show that the best choices is takeout the geomembrane and make embankment by soil that brought from outside ITB-Cirebon.

Table 4. Evaluation Phase Analysis: Decision Making

Alternative	Proposal	Cost	Time	Quality	Functional	Workability	Availability	Durability	Aesthetic	Environment	Safety	Value
1	Keep the Geomembrane	1	5	5	3	3	4	5	1	1	3	3,1
2	Takeout Geomembrane and strengthen the Soil Embankment	5	3	3	5	5	5	2	4	4	3	3,9

5 Point Scale	
Excellent	5
Very Good	4
Good	3
Fair	2
Poor	1

Scoring/scaling are made by cost, time, quality functionality, workability, availability durability environment and safety. The process of this decision making is made by the state of this construction's ponds must be finish without decrease the function of the ponds. The Ponds can accommodate the rain water without the geomembrane but without geomembrane the soil will be absorb the water so the supply of the water will be reduced. Each scoring/scaling is based on the author's preferences. The author tries to make each scoring as objective as possible based on the predecessor analysis phase about functional and cost requirements.

5. Conclusion

Value engineering is an excellent activity that provides superior results in any industry. This leads to noticeable improvements in product or service quality and productivity. While VE is a complex subject, the purpose of this study is to provide a comprehensive understanding of the topic and its many applications. There are several instruments that can be utilized to conduct a VE research. By giving the cognitive process guidance or a framework. As these technologies become more widely available and easier to utilize, more possible applications for VE have been examined. VE has been applied to a wide range of civil engineering issues. It is intended that by conducting this literature review, people will be able to proceed further.

On this case of study, VE is use to improve potential saving on construction phase caused by difference in the implementation of the planning of the field. It saved about 24,7% of initial project cost and can be substitute to another work item. Besides it can reduce the project cost, VE also ensure the Retention Pond can be function properly.

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