Quest Journals
Journal of Architecture and Civil Engineering
Volume 8 ~ Issue 8 (2023) pp: 15-28
ISSN(Online) : 2321-8193
www.questjournals.org

Research Paper

The Application of Value Engineering Method to Cliff Reinforcement and Revitalization of Kanaan Lake in Bontang City by Analytical Hierarcy Process (AHP) Method Approach

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ABSTRACT : *In the implementation of Cliff Reinforcement and Revitalization of Kanaan Lake Project in Bontang City, both parties, the Planning Consultant and the Office of Public Works and Spatial Planning of Bontang City are always facing problem in choosing the right design and implementation method for a realization of buildings which are not only meeting the requirements (in term of design) but built in an economical cost. Related to this discussion, the selection of alternative designs also the suitable eequipments are very important since it will show the quality and cost efficiency of the project's construction.*
The application of Value Engineering in Normalization Excavation Work is carried out by replacing the Amphibious Excavator equipment with the Auger Cutter Suction Dredger and Long Arm + Ponton Excavator equipments. Whereas for the Disposal of Escavated Soil Work, the application of Value Engineering is carried out by replacing the Excavator and Dump Truck equipments with Auger Cutter Suction Dredger and Excavator (helper) equipments. This application study aims to determine the amount of cost saving able to attain after the implementation of Value Engineering.
The result of the study on the Value Engineering application applied on Cliff Reinforcement and Revitalization of Kanaan Lake Project in Bontang City, as performed in two types of earthworks: Normalization Excavation Work and Disposal Excavated Soil Work are successfully obtaining cost saving cost saving after the implementation of Value Engineering (VE) method is Rp. 44.712.692.984.31 with a percentage of 23.24 % from the project value of Rp. 192.358.295.092.81.
KEYWORDS: *Value Engineering, Cliff Reinforcement, Revitalization, Cost Saving.*

R**eceived 08 August, 2023; **R**evised 21 August, 2023; **A**ccepted 23 August, 2023 © The author(s) 2023. **P**ublished with open access at **www.questjournals.org

I. INTRODUCTION

The concept of flood control for Bontang City is created with a consideration to have a whole and integrated handling system starting from upstream part to downstream part of the Bontang watershed. Meanwhile, Lake Kanaan is an artificial lake functions as a flood control building and was built through APBN (state budget) fund. The main function of Kanaan Lake is reducing flood water discharge in Bontang river which passed on from upstream part of Bontang watershed (Suka Rahmat village and its surrounding, East Kutai Regency).

- OP of the year 2015, Initiator: BWS Kalimantan 3, = + 15.155 M^3
- OP of the year 2016, Initiator: BWS Kalimantan 3, = + 10.111 M^3
- OP of the year 2017, Initiator: BWS Kalimantan 3, = + 9.821,74 M^3
- OP of the year 2018, Initiator: BWS Kalimantan 3, = + 8.383,43 M^3
- OP of the year 2019, Initiator: BWS Kalimantan 3, = + 14.924,10 M^3
- OP of the year 2020, Initiator: BWS Kalimantan 3, = + 12.771,79 M^3
- Upgrade the Capacity of Kanaan lake = + 29.576,56 M^3
- OP of the year 2021, Initiator BWS Kalimantan 4, = + 9.817,04 M^3

Bontang City government has a plan to increase the capacity of Kanaan Lake to accommodate flood water by deepening the bottom of the lake. Lake capacity will be upgraded from + 157,332.68 M^3 (2 M1 to 4 M1 depth from the bottom of the lake to the flood water level) to + 566,638.26 M^3 (7 M1 to 8 M1 depth from the lake bottom to the flood water level). The surface water in inundation area of Kanaan Lake will be used as a raw water source (sumber air baku) which later will be processed by PDAM Tirta Taman of Bontang City. So far, Bontang City does not have raw water surface that can be processed and can be utilized as clean water fulfillment for Bontang residents.

Figure 1: Dam Building Condition and Site Plant of Kanaan Lake

The project of Cliff Reinforcement and Revitalization of Kanaan Lake of Bontang City, located on Soekarno Hatta Street, Kanaan village, West Bontang District is planned into major work of Normalization Earthwork which requires a sizeable cost (66.92 %) from the total cost of the construction work. Moreover, the implementation of this project requires long duration time (inefficient) and cost dissipation in some aspects of the work implementation. There are previous researches such as research conducted by Rumkorem and Huda [1] focused on road improvement project, whereas Mahyuddin [2] focused on the construction of Karang Jati Balikpapan Public Health Center residence building. The GAP research of this study focused on cliff reinforcement and lake revitalization project by a value engineering method through the Analytical Hierarchy Process (AHP) method selected for this research.

II. LITERATURE REVIEW

2.1. The Definiton of Value Engineering

According to Hammersley in Tjakra and Walangitan [3] Value Engineering is a process of decision making based on systematic and structured team. Value Engineering aims to achieve the best value for a project/process by defining the functions required to accomplish the value objectives and providing those functions at the lowest cost (overall living cost or resource used) but must be consistent to the quality and performance requested. The definition of Value Engineering can also be interpreted as an organized effort aimed at analyzing the function of a part or system with the aim of achieving the required function at the minimum possible cost but consistent with the provisions for appearance, reliability, quality and maintenance.

In this thesis, the explanation of value engineering is a method of systematic approach to gain maximum results from every cost incurred without reducing the quality, level of trust, performance with in-time delivery (punctual time).

2.2. The Definition of Value Engineering and Value Concept

Especially implemented for a project. According to E.R Fisk in Rozanova and Syarifudin [4], a more specific definition of Value Engineering is a systematic evaluation of the project's engineering design to obtain the highest value for every money spent for studying and thinking about various components of activities, such as procurement, fabrication and construction as well as other activities in relation to costs and functions, with the aim of reducing the overall project costs. According to Zimmerman also cited in Rozanova and Syarifudin [4] the definition of Value Engineering is a management technique that uses a systematic approach to achieve a functional balance between cost, reliability, and performance of a product or project. Furthermore, Rozanova and Syarifudin [4] emphasizing that Value Engineering is not: 1) Design Correction (Review Design) to correct design flaws and not to correct existing design calculations; 2) Low-cost manufacturing processes, for example, not reducing or cutting costs at the expense of quality, reliability, appearance and performance required; 3) Requirements carried out for the entire design is a part of the review schedule of the plan, however, will be more focused on the actual cost and function analysis; 4) Quality Control, which is more than just controlling the quality of a product because it is more than reviewing the reliability status of a design result.

Value Engineering aims to provide something optimal for every money spent by using systematic technique to analyze and control the overall cost of production.

2.3. The Calculation of Values (Calculated Worth)

Estimating the useful value (worth) of each component or subsystem to compare it with the estimated cost is the most difficult part of functional analysis. In the functional analysis, the Value Engineering team compares the cost-to-worth ratios of various alternatives for the entire facility and its subsystems. This cost-to-worth ratio is obtained by dividing the cost for the system or subsystem with the total value of the basic function of the system or subsystem.

2.4. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process is a decision support method develop by a Mathematics Professor, Saaty [5] from the University of Pittsburgh. This is a method used to create an alternative sequence of one decision and as a method of selecting the best alternative of several criteria taken to obtain a goal from the decision.

The Analytical Hierarchy Process model is based on a pairwise comparison matrix where elements in the matrix are the judgment of the decision maker. A decision maker will provide an assessment, giving a perception on it, and estimates the possibility of an event that happens. The matrix is created in every level of hierarchy from an analytical hierarchy process model which will be dissected the whole problem. Some basic principles of Analytical Hierarchy Process can be described as follow:

1. Decomposition

Decomposition is a step in solving or dividing one complete problem in several elements in the form of hierarchical decision-making process, where each element is interconnected to each other. The form of decomposition structure is divided into 3 (three) level. 1) first level: the purpose of decision (goal); 2) second level: the criteria's, 3) third level: the alternatives.

2. Comparative Judgment

Comparative judgment is a stage of making judgments about the relative importance of two elements at a certain level in relation to the level above it. The assessment is presented in the form of a pairwise comparison matrix which contains the preference level of several alternatives for each criterion. A scale preference employed is a scale of 1 (one) into 9 (nine) indicates the lowest level to the highest level.

Table 1. The Analytical Hierarchy Process Assessment Scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one element over another
5	Essential of strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	An element is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The experience favoring one element over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	Compromise is needed between two adjacent values

Source: Saaty [5]

2.5. The Alternatives of Equipment for Normalization Excavation Work

Estimating the useful value (worth) of each component or subsystem to compare it with the estimated cost is the most difficult part of functional analysis. In the functional analysis, the Value Engineering team compares the cost-to-worth ratios of various alternatives for the entire facility and its subsystems. This cost-to-worth ratio is obtained by dividing the cost for the system or subsystem with the total value of the basic function of the system or subsystem.

1. Auger cutter suction dredger (ACSD)

A dredging method by using ACSD will be tested on the project of Cliff Reinforcement and Revitalization of Kanaan Lake in Bontang City. ACSD is a type of dredger from several existing types which capable on moving independently in the water or muddy ground. Its operating machinery system also more varied because apart from its function to move around, the ship also carries out many things in its dredging activity. During operational, this dredger can work in reservoirs, lakes, river channels and swamps. In designing the machining system, there are several parameters which need to be considered, such as the dredging location, the production capacity, the dredging depth, the material type which about to be dredged, the ship size, and the access to the workplace. In the dredging industry, many contractors choose the Auger Cutter Suction Dredger method since this method possess many advantages, such as inexpensive to operate, and (ACSD) is very movable for area with difficult terrain or narrow access like swamps, lakes, and estuaries because of the low requirements for its operation and efficient since ACSD able to operate 24 hours non-stop and gaining optimal dredging result.

2. Excavator long arm + ponton

The dredging method by using Long Arm Excavators + Pontons will be tried on the project of Cliff Reinforcement and Revitalization of Kanaan Lake in Bontang City. The floating ponton is made from iron with measurement of 18 meters long, 6 meters wide and 1.5 meters high above the water level. Its paint has faded of rust, but it still floating on the canal water of Dipasena ponds. Ponton is a very important tool in supporting the work of heavy excavators because without the Ponton, the work will be so difficult for excavators to dredge mud sedimentation up to the fullest. The excavator will be placed on this iron Pontoon to work, including when the excavators is moving from one place to another.

3. Amphibious excavator

The dredging method using an Amphibious Excavator will be tried on the project of Cliff Reinforcement and Revitalization of Kanaan Lake in Bontang City. Amphibious Excavator is a type of excavator equipped with a closed Ponton which allows it to dredge while floating in shallow water. The real key feature from the amphibious undercarriage is fact that excavator can provide buoyancy via hermetically sealed pontoons. The pontoon which is extendable, allow the excavator to float on water by option installed a vertical spud in the absence of solid ground to operate on. The movement is carried out via a track chain using a multi-synchronous hydraulic drive system. Track chains also help assist with floatation, providing a higher level of tractive efficiency and stability over a wider range of ground condition.

III. RESEARCH METHOD

3.1. The Source of Data

The source of data for data collection in this research is consisted from secondary data. The secondary data is type of data obtained from unit price analysis from production capacity analysis, equipment rental market price survey, the related Regional Apparatus Organization (*Organisasi Perangkat Daerah*/OPD) and also through literature studies in libraries and the internet. Literature study is conducted to obtain data, related theories and support research and result of studies regarding research objects in order to solve some of the problems postulated in the research process and research analysis.

3.2. The Data Collection

In this research, the authors are applying the primary data and secondary data with following description:

1. Primary data was an assessment questionnaire on the level of importance.
   - An assessment questionnaire on the level of importance
2. Secondary data utilized in this study were:
   - Base price for construction materials (vendor price survey and/or HSP Bontang City)
   - Base price for construction worker wages (UMK and/or HSP for Bontang City)
   - Data of Equipment production capacity (brochure or tool manual book)
   - Other literatures which supported this research (SNI Standard)
   - Soil investigation (Cone Penetration Test) in the form of Sondir Test

The following are the dependent variables and independent variables in this study:

1. Dependent variables (constraint): efficiency of tool utilization, low implementation cost, short implementation time, and accuracy level of excavation results.
2. Independent variables (free): amphibious excavator, Auger Cutter Suction Dredger (ACSD) and Excavator Long Arm+ Ponton.

3.3. The Information Stages

In this stage, the authors collect related information regarding to the project and other necessary data such as:

Table 2. The Project Data Information

No	Definition	Description
1	Project Name	Technical Planning of Cliff Reinforcement and Revitalization Project of Kanaan Lake Bontang City.
2	Project Owner	Office of Public Works and City Spatial Planning Bontang City
3	Location	Kanaan lake, Kanaan Sub-district, West Bontang District
4	Planning Consultant	CV. Piramid Global Konsultan
5	Cost	Rp. 189.357.696.118,01

3.4. The Speculation Stage

In this stage, a creative approach to the problem is taken by using several alternative ideas as comparison to the initial earthwork plan. The normalization using the initial amphibious excavator equipment is replaced with several alternatives by Auger Cutter Suction Dredger (ACSD) and Excavator Long Arm + Ponton.

3.5. The Analysis Stage

In this study, the authors are applying an Analytical Hierarchy Process concept approach. The authors describe the thinking framework in selecting alternatives taken from several criteria's for selecting the type of riverbank cliffs construction as follows:

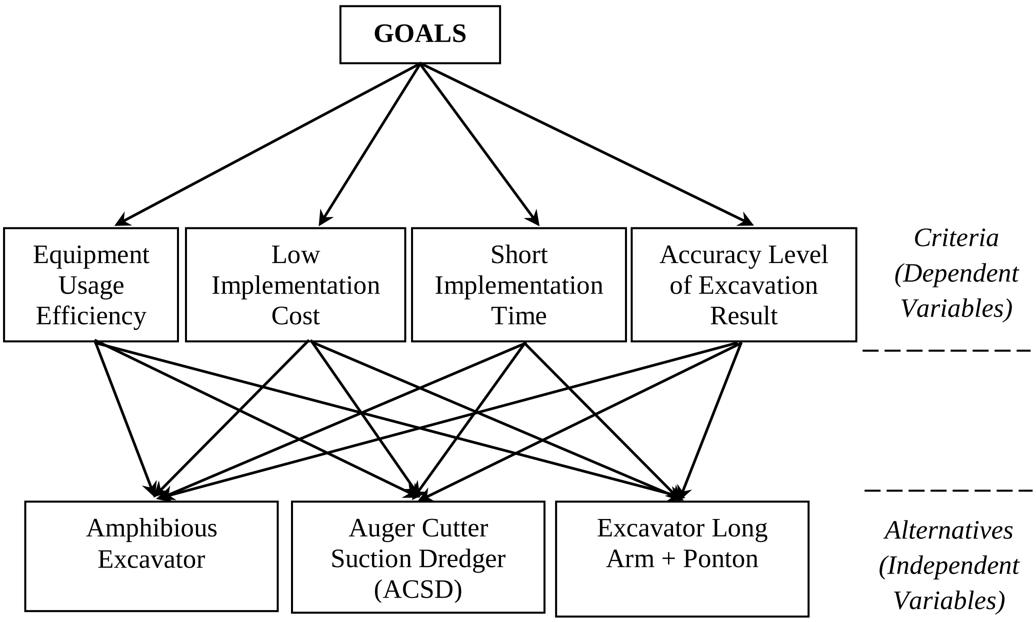

Figure 2: The Decision Diagram

Stages of Analytical Hierarchy Process method are described as follows:

1. Decomposition of the problem, which are described systematically.
2. Assessment or weighing to compare the elements in each hierarchy level based on their relative importance.
3. Arranging a pairwise matrix to normalize the weight of the importance level of each element in their respective hierarchy.
4. Setting the priorities in each hierarchy.
5. Taking or determining decisions. The process where the created alternatives will be selected to find the best alternative based on the criteria.

IV. RESULT AND DISCUSSION

4.1. The Analysis of Activity Cost

The activity cost is the total cost of a project activity which has been prepared as an Activity Cost Budget Plan (*Rencana Anggaran Biaya*/RAB) which includes the VAT and PPh costs. The amount of VAT cost is based on the Law of Republic Indonesia Number 7-year 2021 about the Harmonization of Tax Regulations

(UU HPP) Article 7 paragraph 1 point (a), as of April 1, 2022, has changed from the original value of 10 % to 11 %. Whereas the PPH cost, will be merged into the calculation of each work item unit price.

The result calculation of activity costs for normalization earthworks are presented in series of tables below:

Table 3. AHS Initial Design by Amphbious Excavator

No	Job Description		Item	Quantity Estimation	Unit Price (Rp)	Initial Design (Rp)
1	2		3	4	5	6
A	Earthwork Normalization					
1	Ground Excavation Work Normalization					
	1	Workers	Hour	0.3490	19.571.43	6.830.43
	2	Supervisor	Hour	0.0872	27.400.00	2.389.28
	3	Amphibious Excavator	Hour	0.0872	1.750.000.00	152.600.00
	Amount					**161.819.71**
	10 % profit					**16.181.97**
	Amount (a)					**178.001.68**
	Total Volume of Excavation Normalization = 409,305.58.M^3					
	(c) Total Price of Ground Excavation = Amount (a) x Excavation Volume					**72.857.080.863.96**
2	Excavation soil disposal					
	1	Workers	Hour	0.0694	19,571.43	1,358.26
	2	Supervisor	Hour	0.0694	27,400.00	1,901.56
	3	Excavator	Hour	0.0694	682,266.00	47,349.26
	4	Dump Truck	Hour	0.1926	230,000.00	44,298.00
	Amount					**94,907.08**
	10% profit					**9,490.71**
	Amount (b)					**104,397.79**
	Total Volume of Excavation Soil Disposal = 409,305.58 M^3					
	(d) Total price of Ground Excavation = Amount (b) x Excavation Volume					**42,730,596,106.40**
	(e) Total c + d					**115,587,676,970.36**
	(f) PPn 11 %					**12,714,644,466.74**
	(g) e + f					**128,302,321,437.10**

Table 4. AHS First Alternative Design by ACSD

No	Job Description		Item	Quantity Estimation	Unit Price (Rp)	Initial Design (Rp)
1	2		3	4	5	6
A	Earthwork Normalization					
1	Ground Excavation Work Normalization					
	1	Workers	Hour	0.0030	19.571.43	58.71
	2	Supervisor	Hour	0.0020	27.400.00	54.80
	3	ACSD	Hour	0.0150	6,500,000.00	97,500.00
	4	Amphibious Excavator Helper	Hour	0.0320	1,750,000.00	56,000.00
	5	Excavator Standard (Dump Location)	Hour	0.0200	682,266.00	13,645.32
	Amount					**167,258.83**
	10 % profit					**16,725.88**
	Amount (a)					**183,948.72**

	Total Volume of Excavation Normalization = 409,305.58.M^3				
	(c) Total Price of Ground Excavation = Amount (a) x Excavation Volume				**75,305,971,597.11**
2	Excavation soil disposal				
	No work				
	All included in the normalization				
	excavation work				
	Amount				**-**
	10% profit				**-**
	Amount (b)				**-**
	Total Volume of Excavation Soil Disposal = 409,305.58 M^3				
	(d) Total price of Ground Excavation = Amount (b) x Excavation Volume				**-**
	(e) Total c + d				**75,305,971,597.11**
	(f) PPn 11 %				**8,283,656,875.68**
	(g) e + f				**83,589,628,472.79**

Table 5. AHS Second Alternative Design by Excavator Long Arm + Ponton

No		Job Description	Item	Quantity Estimation	Unit Price (Rp)	Initial Design (Rp)
1		2	3	4	5	6
A		Earthwork Normalization				
1		Ground Excavation Work Normalization				
	1	Workers	Hour	0.3490	19.571.43	6.830.43
	2	Supervisor	Hour	0.0872	27.400.00	2.389.28
	3	Excavator Long Arm 1	Hour	0.0872	1.750.000.00	152.600.00
	4	Excavator Long Arm 2	Hour	0.0290	1,750,000.00	50,750.00
	5	Ponton 1	Hour	0.0307	250,000.00	7,675.00
	6	Ponton 2	Hour	0.1003	250,000.00	25,075.00
	7	Helper Equipment	Hour	1.0000	50.00	
		Amount				**139.204.74**
		10 % profit				**13.920.47**
		Amount (a)				**153,125.22**
		Total Volume of Excavation Normalization = 409,305.58.M^3				
		(c) Total Price of Ground Excavation = Amount (a) x Excavation Volume				**62.675.005.852.59**
2		Excavation soil disposal				
	1	Workers	Hour	0.0694	19,571.43	1,358.26
	2	Supervisor	Hour	0.0694	27,400.00	1,901.56
	3	Excavator	Hour	0.0694	682,266.00	47,349.26
	4	Dump Truck	Hour	0.1926	230,000.00	44,298.00
		Amount				**94,907.71**
		10% profit				**9,490.71**
		Amount (b)				**104,397.79**
		Total Volume of Excavation Soil Disposal = 409,305.58 M^3				
		(d) Total price of Ground Excavation = Amount (b) x Excavation Volume				**42,730,596,106.40**
		(e) Total c + d				**105,405,601,958.99**
		(f) PPn 11 %				**11,594,616,215.49**
		(g) e + f				**117,000,218,174.48**

According to Table 3, 4, and 5 presented above, the calculation obtained is:

- Initial design = Rp. 128,302,321,437.10
- VE design = Rp. 83,589,628,472.79

The amount of cost saving or cost reduction after the implementation of Value Engineering (VE) for *Kanaan* Lake Revitalization project of Bontang city is Rp. 44,712,692,984.31.

- Total project cost = Rp. 192,358,295,092.81
- Percentage from the entire project work after VE implementation =

$$= \frac{\text{Rp. } 44.712.692.984{,}31}{\text{Rp. } 192.358.295.092{,}81} \times 100\% = 23{,}24\%$$

4.2. Analytical Hierarchy Process (AHP)

In making decision by the analytical hierarchy process method, the authors carry out stages of decision-making analysis as stated below:

1. Defining the problem.

At this stage, the authors define the problem into a relationship between goals, criteria and alternatives. The definition of problem being discussed is also explained in the analysis data of research methodology section in figure 2 the decision diagram.

2. Prioritizing the criteria elements.

The authors prioritize the criteria elements through the following stages:

- Analyze the pairwise comparison of each criterion

  The authors analyze the pairwise comparison of each criterion with an objective approach that outlined in the following table:

Table 6. The Pairwise Comparison of Each Criterion

Intensity of Importance	Description
7	Short Implementation Time is **ABSOLUTELY MORE IMPORTANT** than Accuracy Level of Excavation Result
5	Low Implementation Cost is **MORE IMPORTANT** than Short Implementation Time
5	Low Implementation Cost is **MORE IMPORTANT** than Accuracy Level of Excavation Result
3	Efficiency of Small Equipment's Usage is **SLIGHLY MORE IMPORTANT** than Low Implementation Cost
3	Efficiency of Small Equipment's Usage is **SLIGHTLY MORE IMPORTANT** than Short Implementation Time
3	Efficiency of Equipment Usage is **SLIGHTLY MORE IMPORTANT** than Accuracy Level of Excavation Result
1	Two elements compared are **THE SAME** (having the same importance level)

- Creating a pairwise comparison matrix

  Before making a pairwise comparison matrix of each criterion, the authors previously created a symbol to represent each existing criterion as stated below:

  A = Equipment Usage Efficiency
  B = Low Implementation Cost
  C = Short Implementation Time
  D = Accuracy Level of Excavation Result

Table 7. The Pairwise Matrix of Each Criterion

Goal		Criteria			
		A	B	C	D
Criteria	A	1	3	5	7
	B	0.33	1	3	5
	C	0.20	0.33	1	3
	D	0.14	0.20	0.33	1

3. Synthetize the Criterion
   - Calculating the amount values of each criterion

Table 8. The Calculation Matrix for Each Criterion

Goal		Criteria			
		A	B	C	D
Criteria	A	1	3	5	7
	B	0.33	1	3	5
	C	0.20	0.33	1	3
	D	0.14	0.20	0.33	1
Σ		1.68	4.53	9.33	16.00

- Calculating matrix normalized value (eigen value) with the provision of dividing every value from the column by the total column.

Table 9. Matrix Normalized Value (Eigen Value)

Goal		Criteria				Eigen Values			
		A	B	C	D				
Criteria	A	1	3	5	7	0.60	0.66	0.54	0.44
	B	0.33	1	3	5	0.20	0.22	0.32	0.31
	C	0.20	0.33	1	3	0.12	0.07	0.11	0.19
	D	0.14	0.20	0.33	1	0.09	0.04	0.04	0.06
Σ		1.68	4.53	9.33	16.00				

- Calculating value number of normalized matrix (eigen value)

Table 10. Calculation of Matrix Normalized Value (Eigen Value)

Goal		Criteria				Eigen Values				Amount of Eigen Values
		A	B	C	D					
Criteria	A	1	3	5	7	0.60	0.66	0.54	0.44	2.23
	B	0.33	1	3	5	0.20	0.22	0.32	0.31	1.05
	C	0.20	0.33	1	3	0.12	0.07	0.11	0.19	0.49
	D	0.14	0.20	0.33	1	0.09	0.04	0.04	0.06	0.23
Σ		1.68	4.53	9.33	16.00					

- Calculating the average normalized value of the matrix (eigen values) by provision of dividing each number of eigen value from each criterion row by the number of existing criterion elements.

Table 11. Calculation of Matrix Normalized Value (Eigen Value)

Goal		Criteria				Eigen Values				Amount of Eigen Values	Average of Eigen Values
		A	B	C	D						
Criteria	A	1	3	5	7	0.60	0.66	0.54	0.44	2.23	0.56
	B	0.33	1	3	5	0.20	0.22	0.32	0.31	1.05	0.26
	C	0.20	0.33	1	3	0.12	0.07	0.11	0.19	0.49	0.12
	D	0.14	0.20	0.33	1	0.09	0.04	0.04	0.06	0.23	0.06
Σ		1.68	4.53	9.33	16.00						

The average value from the normalized matrix values (average Eigen values) describes the level of importance of an element in each of the existing criteria. The higher the average value, the higher its level of importance.

4. Assessing Consistency to Criterion

In making decision, the level of consistency is crucial element for assuring the decision making will be accomplished without low consistency value. Maximum value of Consistency Ratio (CR) < 0.1 or 10%. Meanwhile, the steps which must be taken are explained below:

- Calculating the Consistency Index (CI) by formulation of:

$$CI = \frac{(\lambda\, maks - n)}{n - 1} \quad \text{...} \ (1)$$

Where:

N = Total amount of criterion elements
= 4
λ maks = Σ {(amount of element columns) x (average eigen element)}
= (1,68x0,56) + (4,53x0,26) + (9,33x0,12) + (16,00x0,06)
= 1,477
Thus, *C1* = $\frac{(4,177-4)}{(4-1)}$ = 0,059

- Calculating the Index Random (IR) by formulation of:

$$IR = \frac{1,98\,(n-2)}{n} \quad \text{..} \ (2)$$

Where:

1, 98 = Fixed number (*Angka Ketetapan*)
n = Amount of criterion elements
= (1,68x0,56) + (4,53x0,26) + (9,33x0,12) + (16,00x0,06)
= 1,477
Thus, *CI* = $\frac{1,98\,(4-2)}{4}$ = 0,99

- Calculating the Consistency Ratio (CR) by formulation of:

$$CR = \frac{CI}{IR} \quad \text{..} \ (3)$$

Where:

CI = Consistency Index
= 0,059
IR = Index Random
= 0,99
Thus, *CR* = $\frac{0,059}{0,99}$ = 0,059 ≤ 0,1 [consistent]

After finishing the comparative analysis on the criteria's, the next step is to carry out a comparative analysis of the alternatives based on the criteria used. The stage analysis process is the same as conducted in the comparative analysis of the criteria as explained below:

a. Analysis to equipment usage efficiency

Table 12. Alternative on Equipment Usage Efficiency Criteria

Equipment Usage Efficiency		A	B	C	Eigen Values		Amount of Eigen Values	Average of Eigen Values
Alternatives	Amphibious Excavator	1	0.11	0.33	0.08	0.04	0.11	0.06
	ACSD	9	1	0.50	0.69	0.32	1.01	0.51
	Excavator Long Arm + Potoon	3	2	1	0.23	0.64	0.87	0.44
Σ		13.00	3.11	1.83				

b. Analysis to low implementation cost

Table 13. Alternative on Low Implementation Cost

Low Implementation Cost		A	B	C	Eigen Values		Amount of Eigen Values	Average of Eigen Values
Alternatives	Amphibious Excavator	1	0.11	0.33	0.08	0.04	0.11	0.06
	ACSD	9	1	0.50	0.69	0.32	1.01	0.51
	Excavator Long Arm + Ponton	3	2	1	0.23	0.64	0.87	0.44
Σ		13.00	3.11	1.83				

c. Analysis to short implementation time

Table 14. Alternative on Short Implementation Time

Short Implementation Time		Alternatives A	Alternatives B	Alternatives C	Eigen Values		Amount of Eigen Values	Average of Eigen Values
Alternatives	Amphibious Excavator	1	0.14	0.25	0.08	0.05	0.13	0.06
	ACSD	7	1	0.50	0.58	0.32	0.90	0.45
	Excavator Long Arm + Ponton	4	2	1	0.33	0.64	0.97	0.48
Σ		12.00	3.14	1.75				

d. Analysis to accuracy level of excavation result

Table 15. Alternative on Accuracy Level of Excavation Result

Accuracy Level of Excavation		Alternatives A	Alternatives B	Alternatives C	Eigen Values		Amount of Eigen Values	Average of Eigen Values
Alternatives	Amphibious Excavator	1	0.14	0.33	0.09	0.05	0.14	0.07
	ACSD	7	1	0.50	0.64	0.64	0.95	0.48
	Excavator Long Arm + Ponton	3	2	1	0.27	0.64	0.91	0.45
Σ		11.00	3.14	1.83				

The final step in this study is analyzing the preferences of each alternative according to the criteria used with the following formula:

Alternative Rank = Σ {(Average Eigen value from Criteria) x (Average Eigen value from Alternatives)}

Table 16. Correction Indicator from Preferences of each Alternative Accomplishes

Criteria		Alternatives					
Type	Average Eigen Value	Excavator Amphibious		ACSD		Excavator Long Arm + Ponton	
		Average Eigen Value	Rank Value	Average Eigen Value	Rank Value	Average Eigen Value	Rank Value
a	b	c	d = b x c	e	f = b x e	g	h = b x g
Equipment Usage Efficiency	0.56	0.06	0.031	0.51	0.283	0.437	0.244
Low Implementation Cost	0.26	0.06	0.015	0.51	0.133	0.437	0.115
Short Implementation Time	0.12	0.06	0.008	0.45	0.055	0.485	0.059
Accuracy Level of Excavation Result	0.06	0.07	0.004	0.48	0.027	0.455	0.026
Total Ranking (Σ)			**0.058**		**0.498**		**0.444**

The correction indicator from preferences of each alternative accomplishes by add up the total ranking of these alternatives, as explained below:

Correction Indicator = Σ Excavator Amphibious + Σ ACSD + Σ Excavator Long Arm + Ponton
= 0,058 + 0,498 + 0,444
= 1 …… (ok)

If the result from correction indicator is equal to 1 (one), then the above calculation can be declared as **CORRECT**. The highest preference value is the alternative chosen in the decision making regarding the type of equipment used in normalization earthworks, found in normalized ground excavation and disposal excavation soil in the Kanaan Lake Revitalization Project of Bontang City.

V. CONCLUSION

According to the Value Engineering analysis which has been discussed in the previous chapter, the authors draw several conclusions of:

1. Application of value engineering method to project of Cliff Reinforcement and Revitalization of Kanaan Lake in Bontang City can be carried out within the following types of work:
   a. Normalization Excavation work.
   b. Disposal of excavation soil.

2. There are two best alternative designs which able to replace the selected type of work:
   a. Normalization Excavation Work.
      - Initial Design:
        The initial design is employing Amphibious Excavator.
      - Alternative Design:
        1) Replacing equipment for Normalization excavation work by using Auger Cutter Suction Dredger (ACSD) equipment.
        2) There is an obtainable cost saving of Rp.44.712.692.984.31 from 2 (two) types of work; Normalization excavation work and disposal of excavation soil. Both works are inseparable because the function of ACSD's main equipment is acted as a dredger for cutting excavated ground while at the same time sucking up the excavated material which then be channeling through a suction pipe to the disposal area until maximum distance of 1 (one) kilometer from the ACSD's work site.
      - The benefits can be obtained from the alternative design are:

1) Easy to work with.
2) The normalization excavation work can be progressed faster (time efficiency)
3) There is an obtainable cost saving from this alternative option.

b. Disposal of Excavation Soil
- Initial Design:
  The disposal of excavated soil was originally executed by using excavators and dump trucks.
- Alternative Design
  1) Replaces the equipment for disposal excavated soil by Auger Cutter Suction Dredger (ACSD) equipment.
  2) No more cost longer incurred in the work of disposal excavation soil.
- The benefits can be obtained from the alternative design are:
  1) Easy to work with.
  2) Time for carrying out the disposal excavation soil can be faster (time efficiency)
  3) There is an obtainable cost saving from this alternative option.

The amount of cost saving after the implementation of Value Engineering (VE) method is Rp. 44.712.692.984.31 with a percentage of 23.24 % from the project value of Rp. 192.358.295.092.81.

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