DEVOTION Journal of Research and Community Service
Volume 3, Number 14, December 2022
e-ISSN: 2797-6068 and p-ISSN: 2777-0915

VALUE ENGINEERING IN PLANNING CONSTRUCTION OF AMPELSARI RESERVOIR PASURUAN REGENCY

Cornelius Umarwoko Daniarto, Wateno Oetomo, Esti Wulandari
Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: cornel.dani82@gmail.com, wateno@untag-sby.ac.id, wulandariesti@untag-sby.ac.id

KEYWORDS
value engineering, cost saving, embung

ABSTRACT
Controlling the cost and time of project implementation is important in a project management process. In this research, a value engineering analysis will be carried out on the Ampelsari Reservoir construction plan to determine the most effective and cost-efficient alternative construction design. The application of value engineering to determine the amount of construction cost savings with a work plan includes: Information Stage, Creative Stage, Analysis Stage, and Recommendation Stage. The results of the value engineering analysis in this study obtained construction cost savings of Rp. 1,624,162,703.65 or 6.16% of the total initial design cost, with alternative designs selected in 3 (three) types of work, on Spillway Work with K-225 Reinforced Concrete and Cyclop Concrete work items (A3), on Gate Valve House Work with Concrete Rebate and U-Ditch 30 x 30 work items (B3), on Reservoir Work with HDPE Pipe work items dia. 2.5" (C2). 2.5" (C2)

INTRODUCTION

In carrying out a building or other structure construction project, a fee is required so that the project can run. Before the building owner decides to proceed with the project to the design and construction stage, a budget needs to be prepared in advance (Andriani et al., 2019). This budget is often an obstacle, because it is a limit to the amount of money that must be spent to carry out a construction project. But everyone is interested in saving costs and everyone is trying to find an investment that can generate the maximum return on investment (Amir & Zakia, 2018). The application of value engineering in the field of construction is an approach that is carried out systematically by a team of many disciplines that focuses on value and function. The application of Value Engineering in construction projects has the potential for considerable savings from the project budget. The application of value engineering in construction projects, the techniques and alternatives used are different, this is due to the approach used, cultural conditions, and different procurement systems (Putra et al., 2018). There are still many inefficiencies in the implementation of building construction at this time, so it is necessary to carry out a design review or value engineering so that unnecessary costs and efforts can be eliminated or reduced so that the value or cost of the project can be even more economical. (Syafira et al., 2020).

The plan to build the Ampelsari Reservoir in Ampelsari Village, Pasrepan District, Pasuruan Regency is one of the efforts to conserve water, and use it for raw water needs and irrigation water, as well as reduce flooding (Bahri & Indryani, 2018). The Ampelsari Reservoir is planned to be 14.6 m high, 50.65 m long, with an inundation area of 5,384 m2 and a storage volume of 19,062 m3. Construction of the body of the reservoir is planned in the form of landfill imported from the Borrow Area. The benefits of the reservoir are to supply the raw water needs of the Ampelsari village of 6.39 l/s and also to supply irrigation for the Wijeng Irrigation Area of 88 Ha with a Paddy-Palawija-Palawija cropping pattern with a Planting Index of 260% and an operational reliability of 88%. In addition, the Ampelsari Embung has the potential to reduce flood peaks by 78% with an inflow of 39.92 m3/sec and an outflow of 8.66 m3/sec (Baskara, 2019).

In this research, value engineering analysis will be carried out in the Embung Ampelsari construction plan to determine the most effective and efficient construction design alternatives. So that it can determine the amount of construction cost savings with the application of value engineering (Bertolini et al., 2015).

Value Engineering (*Value Engineering*)

Value engineering is the systematic evaluation of the engineering design of a project to get the most value for each dollar spent. Furthermore, Value Engineering examines and considers the 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 overall project costs. (Fisk et al., 1982)

The definition of value engineering related to use in construction projects (Zimmerman & Hart, 1982) is:

1. *An Oriented System,* an identification technique, eliminates unnecessary costs
2. *A Multidiciplin Team Approach,* a cost-saving technique involving the entire team, across multiple fields.
3. *A Proven Management Tecnique,* a proven and guaranteed cost saving technique
4. *An Oriented Function,* oriented to the function required for each item
5. *Life Cycle Cost Oriented,* oriented to the total costs required during the production process, optimizing operations.

Information Stage

Pareto Charts

A Pareto chart is a bar chart combined with a line chart to show a parameter being measured. It can be a frequency of occurrence or a certain value, so that the dominant parameter can be identified. Become a standard method in quality control in order to get maximum results. Also considered as a form of a simple approach that is easily understood by workers, and can be used as a solution tool in complex fields (Diputera et al., 2018).

The Pareto principle is a logical approach to a probability distribution that has a strong rule of thumb that coincides with the social sciences, science, geophysics, and those related to estimation. Often referred to as the 80-20 principle. This is because this principle states that about 80% of results are actually produced by 20% of inputs or drives (Ani Firda, 2018).

***Cost/Worth* Ratio**

The function analysis process uses the *Cost/Worth* (C/W) ratio equation which analyzes the cost of elements with the cost of the function of these elements (Retno & Hastuti, 2002).

Index Function Analysis = Cost / Worth

Where *cost* is the total cost of a work item and *worth* is a form of cost that only has a functional value to that work item. In the function analysis stage, if the index value is obtained > 1, then some of these work items have the potential to be carried out *by Value Engineering*. A high *cost-to-worth* ratio for a work item indicates that the work item has high cost savings, and will be selected for further analysis (Khamim & Harsanti, 2015).

Analysis Stage

***Zero - One* matrix**

The zero-one matrix is a decision-making method that aims to determine the priority order of functions (criteria). The principle of this method is to determine the relativity of a "more important" or "less important" function to other functions. Functions that are "more important" are given a value of one, while values that are "less important" are given a value of zero (Mahyuddin, 2020). Then by comparison an index will be obtained for each criterion which will later become a calculation parameter in determining the value of decision making for each alternative based on predetermined criteria. (Julien, 1999)

RESEARCH METHOD

The subject of this study was the planning for the development of the Ampelsari Embung in Ampelsari Village, Pasrepan District, Pasuruan Regency, East Java Province, and the researchers made a comparison of the initial designs by analyzing alternative construction designs, calculating the volume of work and calculating the construction costs of all design alternatives.

RESULTS AND DISCUSSION

Information Stage

Project information, basic project data in this study are based on the results of the detailed planning of the Ampelsari Embung design which has been carried out within the Brantas River Basin Center. The budget plan data for the construction of the Ampelsari Embung are as follows.

Table 1
Recapitulation of the Project Cost Budget Plan

No	Job description	Total price
1	Preparatory work	Rp. 39,042,235.24
2	Reservoir Body Work	Rp. 4,226,745,701.67
3	Spillway work (overflow)	Rp. 5,693,832,457.09
4	Intake work (inlet-outlet)	Rp. 1,251,317,923.03
5	Gate Valve Homework	Rp. 2,183,572,627.64
6	Reservoir Work	Rp. 1,491,079,673.45
7	Public Hydrant Works	Rp. 1,383,675,256.15

8	Complementary Building Works	Rp. 1,088,156,308.09
	TOTAL NUMBER	Rp. 15,557,422,182.35

Source: BBWS Brantas, 2020

Breakdown Costs

Breakdown cost to identify elements of work that have the potential to have a high level of cost and value engineering analysis can be carried out next.

Table 2
***Breakdown Cost* Project Cost**

NO.		JENIS PEKERJAAN	SATUAN	VOLUME PEKERJAAN	HARGA SATUAN PEKERJAAN (Rp.)	JUMLAH HARGA (Rp.)
I	**Pekerjaan Persiapan**					**39.042.235,24**
	1.1	Mobilisasi & Demobilisasi Alat	Ls	1,00	14.720.000,00	14.720.000,00
	1.2	Uitset SItuasi Embung	M'	1.000,00	3.925,08	3.925.081,84
	1.3	Pengadaan dan Pemasangan Patok Kayu	Bh	20,00	18.597,80	371.955,90
	1.4	Dewatering	Jam	105,88	189.140,00	20.025.197,50
II	**Pekerjaan Tubuh Embung**					**4.226.745.701,67**
	2.1	Clearing Grubbing (Pengupasan lapisan top soil)	M2	900,00	25.434,00	22.890.600,00
	2.2	Galian Tanah	M3	4.457,03	36.109,45	160.940.817,41
	2.3	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	4.457,03	45.901,77	204.585.477,85
	2.4	Tanah dihampar, diratakan dan dirapikan	M3	4.457,03	32.109,06	143.110.999,78
	2.5	Timbunan Tanah Pilihan (dari borrow jarak 10 km)	M3	9.614,58	322.024,15	3.096.128.275,46
	2.6	Geotextile non woven	M2	962,88	51.292,92	49.388.721,84
	2.7	Pasangan Batu Kosong (Rip-Rap)	M3	876,06	522.246,54	457.518.262,38
	2.8	Gebalan rumput	M2	1.839,00	32.000,00	58.848.000,00
	2.9	V Notch	Ls	1,00	33.334.546,95	33.334.546,95
III	**Pekerjaan Spillway (Pelimpah)**					**5.693.832.457,09**
	3.1	Clearing Grubbing (Pengupasan lapisan top soil)	M2	500,00	25.434,00	12.717.000,00
	3.2	Galian Tanah	M3	16.558,48	36.109,45	597.917.726,01
	3.3	Timbunan Tanah Kembali	M3	167,31	68.105,97	11.394.810,27
	3.4	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	16.391,17	45.901,77	752.383.940,18
	3.5	Tanah dihampar, diratakan dan dirapikan	M3	16.391,17	32.109,06	526.305.283,37
	3.6	Pasangan Batu Kosong	M3	24,00	522.246,54	12.533.917,04
	3.7	Pasangan Batu Dengan Mortar (Campuran 1PC : 4PP)	M3	2.251,88	1.552.542,40	3.496.136.078,38
	3.8	Pasangan Beton (K-300)	M3	22,08	3.359.821,83	74.184.865,98
	3.9	Siaran Dengan Mortar (Campuran 1PC : 2PP)	M2	1.237,00	150.462,51	186.122.120,92
	3.10	Plesteran Dengan Mortar (Campuran 1PC : 3PP)	M2	159,50	151.327,37	24.136.714,94

NO.		JENIS PEKERJAAN	SATUAN	VOLUME PEKERJAAN	HARGA SATUAN PEKERJAAN (Rp.)	JUMLAH HARGA (Rp.)
IV	**Pekerjaan Intake (inlet - outlet)**					**1.451.317.923,03**
	4.1	Clearing Grubbing (Pengupasan lapisan top soil)	M2	200,00	25.434,00	5.086.800,00
	4.2	Galian Tanah	M3	115,55	36.109,45	4.172.266,08
	4.3	Timbunan Tanah	M3	59,27	68.105,97	4.036.807,85
	4.4	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	56,27	45.901,77	2.583.009,69
	4.5	Tanah dihampar, diratakan dan dirapikan	M3	56,27	32.109,06	1.806.858,94
	4.6	Pasangan Beton (K-300)	M3	163,59	3.359.821,83	549.649.749,69
	4.7	Plesteran Dengan Mortar (Campuran 1PC : 3PP)	M2	25,09	151.327,37	3.796.470,70
	4.8	Trash Rack	Bh	1,00	644.231,90	644.231,90
	4.9	Pipa GIP Ø 10"	M'	95,00	8.912.389,51	846.677.003,04
	4.10	Gate Valve Ø 10"	Bh	1,00	17.276.137,94	17.276.137,94
	4.11	Gate Valve Ø 2,5"	Bh	1,00	3.363.437,94	3.363.437,94
	4.12	Elbow Ø 10"	Bh	2,00	4.466.402,94	8.932.805,88
	4.13	Reducer Ø 10" X Ø 2.5"	Bh	1,00	1.095.350,44	1.095.350,44
	4.14	Tee Ø 10"	Bh	1,00	2.196.992,94	2.196.992,94
V	**Pekerjaan Rumah Gate Valve**					**2.183.572.627,64**
	5.1	Galian Tanah	M3	6.077,42	36.109,45	219.452.312,94
	5.2	Timbunan Tanah	M3	22,87	68.105,97	1.557.549,54
	5.3	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	6.054,55	45.901,77	277.914.635,45
	5.4	Tanah dihampar, diratakan dan dirapikan	M3	6.054,55	32.109,06	194.405.984,97
	5.5	Timbunan Pasir	M3	369,55	261.926,28	96.794.596,48
	5.6	Pasangan Batu Kali (1:4)	M3	584,56	1.552.542,40	907.559.620,22
	5.7	Plesteran Dengan Mortar (Campuran 1PC : 3PP)	M2	845,60	151.327,37	127.961.664,37
	5.8	Paving	M2	1.960,20	115.000,00	225.423.000,00
	5.9	Pasir Urug	M3	196,02	261.926,28	51.342.790,27
	5.10	Pasangan Beton (K-225)	M3	26,00	3.121.969,43	81.160.473,40
VI	**Pekerjaan Reservoir**					**1.491.079.673,45**
	6.1	Galian Tanah	M3	515,27	36.109,45	18.606.042,66
	6.2	Timbunan Tanah	M3	247,32	68.105,97	16.843.969,13
	6.3	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	267,95	45.901,77	12.299.287,69
	6.4	Tanah dihampar, diratakan dan dirapikan	M3	267,95	32.109,06	8.603.559,63
	6.5	Lantai Kerja	M3	16,94	1.293.722,42	21.910.482,83
	6.6	Pasangan Beton (K-225)	M3	51,73	3.121.969,43	161.511.966,47
	6.7	Paving	M2	95,76	115.000,00	11.012.400,00
	6.8	Pasir Urug	M3	9,58	261.926,28	2.508.206,10
	6.9	Pipa GIP Ø 2,5"	M'	690	1.793.889,51	1.237.783.758,94
VII	**Pekerjaan Hidran Umum**					**1.383.675.256,15**
	7.1	Galian Tanah Manual	M3	822,00	100.568,63	82.667.416,01
	7.2	Timbunan Tanah	M3	360,40	68.105,97	24.545.392,51
	7.3	DT. Angkut Material Atau Hasil Galian Sejauh 5 Km	M3	461,60	45.901,77	21.188.257,42
	7.4	Tanah dihampar, diratakan dan dirapikan	M3	461,60	32.109,06	14.821.544,20
	7.5	Pasangan Batu Dengan Mortar (Campuran 1PC : 4PP)	M3	11,00	1.552.542,40	17.077.966,42
	7.6	Paving	M2	25	115.000,00	2.875.000,00
	7.7	Pasir Urug	M3	2,50	261.926,28	654.815,71
	7.8	Pipa GIP Ø 2,5"	M'	680	1.793.889,51	1.219.844.863,89
VIII	**Pekerjaan Bangunan Pelengkap**					**1.088.156.308,09**
	8.1	Solar cell	Bh	46,00	10.228.937,94	470.531.145,15
	8.2	Pagar BRC	M'	190,50	469.342,03	89.409.657,17
	8.3	Tiang Pagar BRC	M'	80,00	313.564,95	25.085.195,92
	8.4	Rumah Jaga	M2	36,00	3.468.160,01	124.853.760,32
	8.5	Jalan Puncak Embung	Ls	1,00	58.284.317,02	58.284.317,02
	8.6	Jalan Akses	Ls	1,00	294.992.232,51	294.992.232,51
	8.7	Nomenklatur Bangunan	Ls	1,00	5.000.000,00	5.000.000,00
	8.8	Landscap	Ls	1,00	20.000.000,00	20.000.000,00
	JUMLAH TOTAL					**Rp 17.557.422.182,35**

Source: BBWS Brantas, 2020

Pareto Charts

Pareto chart to identify and classify work items according to the project plan and the amount of the planned costs. Next, make a list and order the amount of the cost plan from the largest to the lowest cost plan. By calculating the cumulative quantity and cumulative percentage, a Pareto chart can be drawn.

Table 3
Project Cost Percentage Ranking

No	Uraian Pekerjaan	Jumlah Harga		Prosentase	Komulatif Harga		Prosentase Komulatif
1	Spillway (Pelimpah)	Rp	5.693.832.457,09	32,43%	Rp	5.693.832.457,09	32,43%
2	Tubuh Embung	Rp	4.226.745.701,67	24,07%	Rp	9.920.578.158,76	56,50%
3	Rumah Gate Valve	Rp	2.183.572.627,64	12,44%	Rp	12.104.150.786,40	68,94%
4	Reservoir	Rp	1.491.079.673,45	8,49%	Rp	13.595.230.459,85	77,43%
5	Intake (inlet - outlet)	Rp	1.451.317.923,03	8,27%	Rp	15.046.548.382,88	85,70%
6	Hidran Umum	Rp	1.383.675.256,15	7,88%	Rp	16.430.223.639,03	93,58%
7	Bangunan Pelengkap	Rp	1.088.156.308,09	6,20%	Rp	17.518.379.947,11	99,78%
8	Persiapan	Rp	39.042.235,24	0,22%	Rp	17.557.422.182,35	100,00%
	Jumlah Total	**Rp**	**17.557.422.182,35**	**100,00%**			

Source: Analysis, 2022

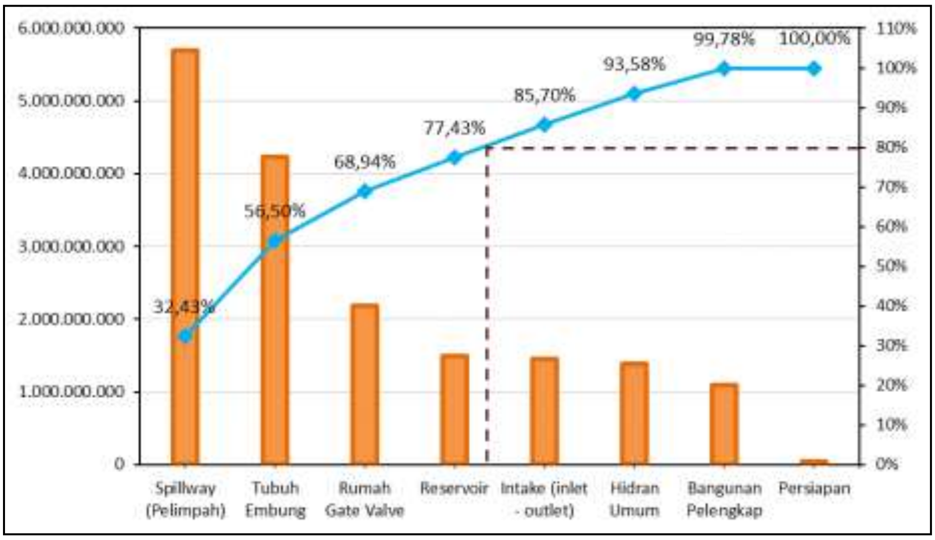

Figure 1
Project Pareto Chart
Source: Analysis, 2022

The results of the Pareto Diagram analysis with the 80%/20% law on the overall project cost plan, there are 4 (four) types of work that have the potential to be value engineered, namely:

1. *Spillway* Work
2. Reservoir Body Work
3. *Gate Valve* Homework
4. *Reservoir* Work (Reservoir)

Furthermore, for 4 (four) types of work, Pareto Diagram analysis was carried out to determine work items that could be value engineered.

1. Abundant Work

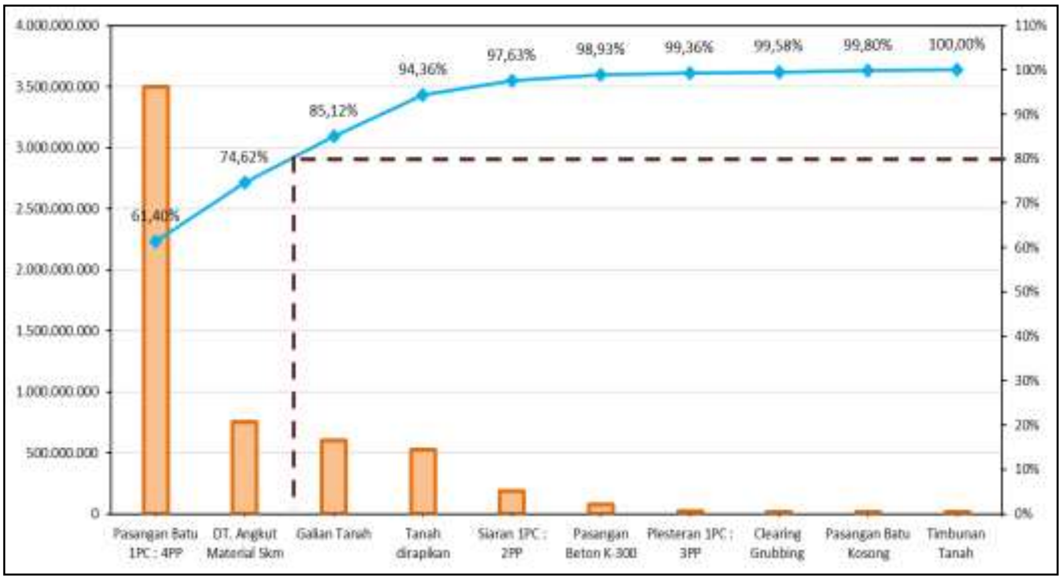

Figure 2
Overflow Jobs Pareto Chart
Source: Analysis, 2022

The results of the Pareto Diagram analysis on Overflowing Works, there are 2 (two) work items that have the potential for value engineering, namely:

- ➢ Stone Pair 1PC : 4PP
- ➢ *Dump Truck* Transporting Materials a distance of 5 km

2. Reservoir Body Work

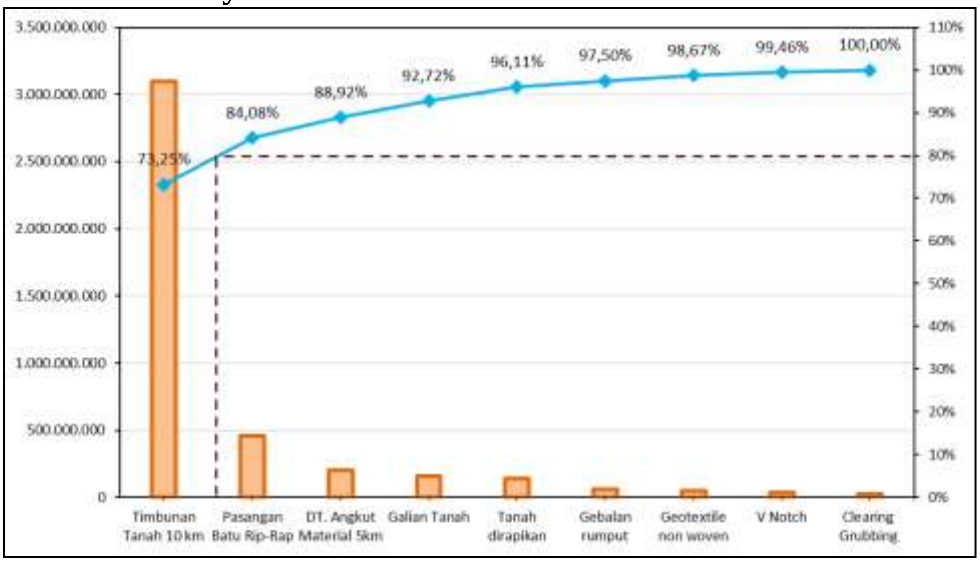

Figure 3
Reservoir Body Work Pareto Chart
Source: Analysis, 2022

The results of the Pareto Diagram analysis on the Reservoir Body Work, there is 1 (one) work item that has the potential for value engineering, namely:

- ➢ Heaps of Preferred Land 10 km away

3. *Gate* Valve Homework

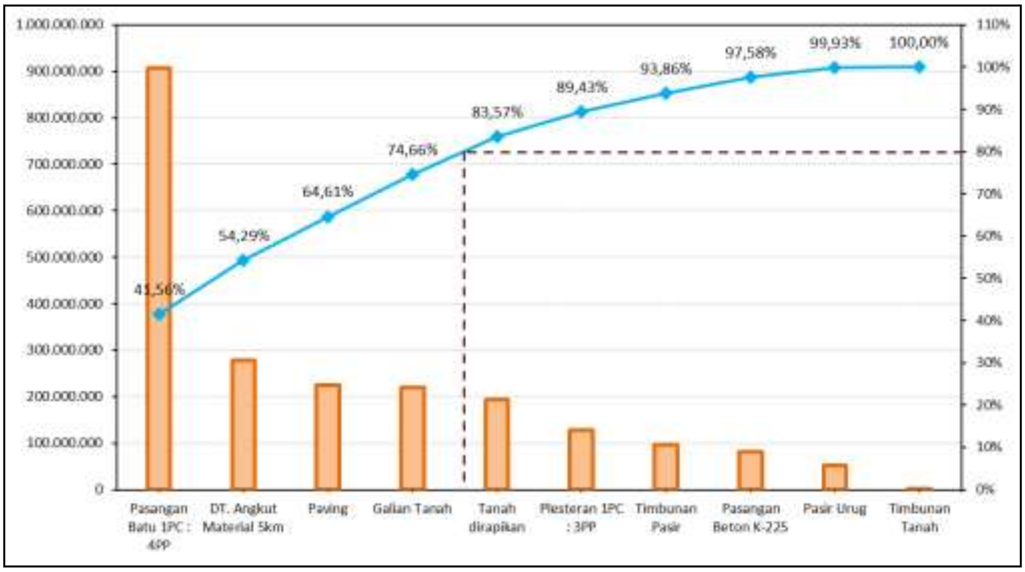

Figure 4

***Gate Valve* Homework Pareto Diagram**

Source: Analysis, 2022

The results of the Pareto Diagram analysis on *Gate Valve* Homework, there are 4 (four) work items that have the potential for value engineering, namely:

- ➢ Stone Pair 1PC : 4PP
- ➢ *Dump Truck* Transporting Materials a distance of 5 km
- ➢ paving
- ➢ Soil excavation

4. *Reservoir* Work

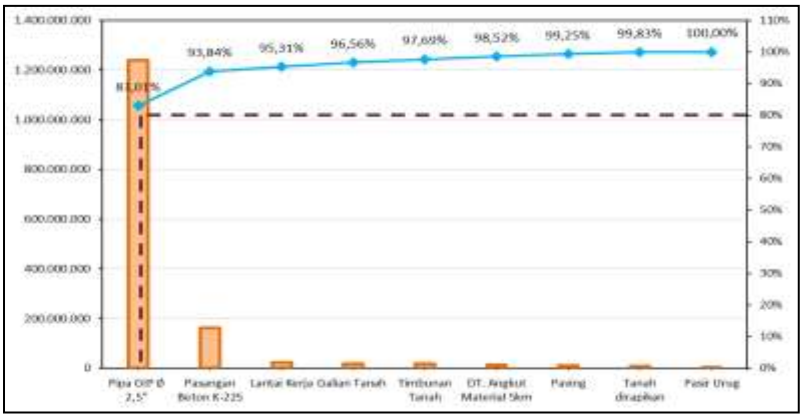

Figure 5

***Reservoir* Work Pareto Chart**

Source: Analysis, 2022

The results of the Pareto Diagram analysis on *Reservoir Works*, there is 1 (one) work item that has the potential for value engineering, namely:

- GIP pipe 2.5" diameter

Cost/Worth Ratio

Function analysis using the *Cost/Worth ratio equation* which analyzes the cost of work items with the cost of work item functions, based on the price of each work item. By analyzing the main function (Primary) and supporting function (Secondary), so as to know the comparison between the costs and the value of the benefits needed to produce these functions. In the function analysis stage, if the value of the *Cost/Worth ratio index* is obtained > 1 then the work item has the potential to be subject to value engineering analysis at a later stage. The results of the analysis for each type of work that has the potential to be value engineered are as follows:

Table 4
***Cost/Worth* Function Analysis**

No.	Job description	cost	Worth	C/W ratio
1	*Spillway* Work _	5,693,832,457.09	3,496,136,078.38	1.63
2	Reservoir Body Work	4,226,745,701.67	3,096,128,275.46	1.37
3	Gate Valve Homework	2,183,572,627.64	988,720,093.62	2,21
4	Reservoir Work	1,491,079,673.45	1,237,783,758.94	1.20

Source: Analysis, 2022

In the function analysis stage, it is obtained that the index value of the *Cost/Worth ratio* is obtained > 1, so the work item has the potential for value engineering analysis to be carried out at a later stage.

Based on the results of the analysis of the Pareto Chart and the *Cost/Worth Ratio*, it is known that there are 4 (four) types of work that have the potential to carry out value engineering analysis. However, for the type of pond body work, no further analysis is carried out, because the work item for selected landfills at a distance of 10 km is a work item that is planned to be taken from *the quarry area at a* distance of 10 km, which has been analyzed and determined during the initial design planning, starting from soil data, stability and sufficient volume availability for homogeneous backfill embankment material. So that 3 (three) types of work will be carried out in the next stage of value engineering at the creative stage. that is:

1. *Spillway* Work
2. *Gate Valve* Homework
3. *Reservoir* Work (Reservoir)

Creative Stage

The creative stage is to formulate and think about other alternatives that can fulfill the same use or function as the initial plan. Based on the results of the analysis at the information stage, the types and items of work that can be carried out by design alternatives are obtained, including the following:

Table 5
Abundant Job Alternatives

No	Code	Job description
1	A1	Stone Pair 1PC : 4PP
2	A2	K225 Reinforced Concrete & Fitting. Stone 1PC : 4PP
3	A3	K225 Reinforced Concrete & Cyclops Concrete

Source: Analysis, 2022

Table 6
***Gate Valve* Homework Alternatives**

No	Code	Job description
1	B1	Stone Pair 1PC : 4PP
2	B2	Rebate & Fitting Concrete. Stone 1PC : 4PP
3	B3	Rebate Concrete & U-Ditch 30 x 30

Source: Analysis, 2022

Table 7
***Reservoir* Job Alternatives**

No	Code	Job description
1	C1	GIP pipe dia. 2.5"
2	C2	HDPE pipe dia. 2.5"
3	C3	PVC pipe AW dia. 2.5"

Source: Analysis, 2022

Analysis Stage

The analysis phase, in selecting project alternatives, is always related to determining the best of the available alternatives.

Implementation Costs

Analysis of the budget plan based on the design alternatives that have been determined.

Table 8
Recapitulation of Alternative Design Budget Plans

No	Code	Job description	Price Friday (Rp.)	Cost Savings (Rp.)
I	**A**	**Abundant Work**		
1	A1	Stone Pair 1PC : 4PP	5,693,832,457.09	-
2	A2	K225 Reinforced Concrete & Fitting. Stone 1PC : 4PP	5,581,351,755.23	112,480,701.86

3	A3	K225 Reinforced Concrete & Cyclops Concrete	5,497,207,098.27	196,625,358.82
II	**B**	***Gate Valve* Homework**		
1	B1	Stone Pair 1PC : 4PP	2,183,572,627.64	-
2	B2	Rebate & Fitting Concrete. Stone 1PC : 4PP	1,693,046,869.78	490,525,757.86
3	B3	Rebate Concrete & U-Ditch 30 x 30	1,541,912,231.04	641,660,396.60
III	**C**	***Reservoir* Work**		
1	C1	GIP pipe dia. 2.5"	1,491,079,673.45	-
2	C2	HDPE pipe dia. 2.5"	705,202,725.22	785,876,948.23
3	C3	PVC pipe AW dia. 2.5"	646,791,241.29	844,288,432.16

Source: Analysis, 2022

Alternative Determination

Feasibility Analysis

Next is the development stage of the analysis results from the previous stage. To select the best alternative using the *zero-one method* to find the weight of the proposed criteria according to the results of the feasibility analysis. The criteria in the feasibility analysis are as follows:

I. Plan Budget 0 = Expensive 10 = Inexpensive
II. Job Implementation Time 0 = Long 10 = Fast
III. Material Availability 0 = Difficult 10 = Easy
IV. Design Technical 0 = Not Compliant 10 = Safe
V. Function Effectiveness 0 = Ineffective 10 = Effective
VI. Work Execution Method 0 = Complicated 10 = Simple
VII. Human Resources 0 = Many 10 = Few
VIII. Supervision of Implementation 0 = Strict 10 = Normal

Table 9

Results of the Overflow Job Feasibility Analysis

NO	KODE	ALTERNATIF	KRITERIA								JUMLAH	PERINGKAT
			I	II	III	IV	V	VI	VII	VIII		
1	A1	Pasangan Batu 1PC : 4PP	6	5	6	8	7	9	7	7	55	3
2	A2	Beton Bertulang K225 & Pas. Batu 1PC : 4PP	8	7	7	6	8	6	8	6	56	2
3	A3	Beton Bertulang K225 & Beton Cyclop	9	9	7	7	8	7	9	8	64	1

Source: Analysis, 2022

Table 10
***Gate Valve* Homework**

NO	KODE	ALTERNATIF	KRITERIA								JUMLAH	PERINGKAT
			I	II	III	IV	V	VI	VII	VIII		
1	B1	Pasangan Batu 1PC : 4PP	6	5	6	8	7	9	7	7	55	3
2	B2	Beton Rabat & Pasangan Batu 1PC : 4PP	8	7	7	6	8	6	8	6	56	2
3	B3	Beton Rabat & U-Ditch 30 x 30	9	9	7	7	8	7	9	8	64	1

Source : Analysis, 2022

Table 11
***Reservoir* Job Feasibility Analysis Results**

NO	KODE	ALTERNATIF	KRITERIA								JUMLAH	PERINGKAT
			I	II	III	IV	V	VI	VII	VIII		
1	C1	Pipa GIP dia. 2,5"	5	3	5	9	6	6	8	6	48	3
2	C2	Pipa HDPE dia. 2,5"	9	7	7	8	8	7	7	7	60	1
3	C3	Pipa PVC AW dia. 2,5"	10	6	7	5	7	8	6	8	57	2

Source : Analysis, 2022

Table 12
***Zero - One* Method Criteria Weight**

NO.	KRITERIA	KODE	KODE								JUMLAH	PERINGKAT
			I	II	III	IV	V	VI	VII	VIII		
1	Rencana Anggaran Biaya	I	x	1	1	1	1	1	1	1	7	1
2	Waktu Pelaksanaan Pekerjaan	II	1	x	1	1		1	1	0	5	3
3	Ketersediaan Material	III	0	0	x	0	0	0	0	0	0	8
4	Teknis Desain	IV	1	0	1	x	1	1	1	1	6	2
5	Efektifitas Fungsi	V	0	0	0	1	x	0	0	0	1	7
6	Metode Pelaksanaan Pekerjaan	VI	1	1	0	1	0	x	1	0	4	4
7	Sumber Daya Manusia	VII	1	1	0	0	0	1	x	0	3	5
8	Pengawasan Pelaksanaan	VIII	1	0	0	1	0	0	0	x	2	6

Source: Analysis, 2022

Table 13
Criteria weight recapitulation

NO	CRITERIA	CODE	RATING	WEIGHT
1	Budget plan	I	1	25.00%
2	Design Technical	IV	2	21.43%
3	Time of execution of work	II	3	17.86%
4	Work Implementation Methods	VI	4	14.29%
5	Human Resources	VII	5	10.71%
6	Implementation Supervision	VIII	6	7.14%
7	Function Effectiveness	V	7	3.57%
8	Availability of Materials	III	8	0.00%

Source: Analysis, 2022

After obtaining the weight values of all the alternative criteria used, the final weighting is carried out with an evaluation matrix. Part of this method is to find out the priority value of an item that is presented by evaluating alternatives for each type of work.

Table 14
Overflow Job Alternative Evaluation Matrix

No	Kriteria	Bobot	Alternatif					
			A1		A2		A3	
1	I	25,00%	6	150%	8	200%	9	225%
2	II	17,86%	5	89%	7	125%	9	161%
3	III	0,00%	6	0%	7	0%	7	0%
4	IV	21,43%	8	171%	6	129%	7	150%
5	V	3,57%	7	25%	8	29%	8	29%
6	VI	14,29%	9	129%	6	86%	7	100%
7	VII	10,71%	7	75%	8	86%	9	96%
8	VIII	7,14%	7	50%	6	43%	8	57%
	Jumlah	**100,00%**	**689%**		**696%**		**818%**	
	Peringkat		**3**		**2**		**1**	

Source: Analysis, 2022

Table 15
***Gate Valve* Work Alternative Evaluation Matrix**

No	Kriteria	Bobot	Alternatif					
			B1		B2		B3	
1	I	25,00%	6	150%	8	200%	9	225%
2	II	17,86%	5	89%	7	125%	9	161%
3	III	0,00%	6	0%	7	0%	7	0%
4	IV	21,43%	8	171%	6	129%	7	150%
5	V	3,57%	7	25%	8	29%	8	29%
6	VI	14,29%	9	129%	6	86%	7	100%
7	VII	10,71%	7	75%	8	86%	9	96%
8	VIII	7,14%	7	50%	6	43%	8	57%
	Jumlah	**100,00%**	**689%**		**696%**		**818%**	
	Peringkat		**3**		**2**		**1**	

Source: Analysis, 2022

Table 16
***Reservoir* Job Alternative Evaluation Matrix**

No	Kriteria	Bobot	Alternatif					
			C1		C2		C3	
1	I	25,00%	5	125%	9	225%	10	250%
2	II	17,86%	3	54%	7	125%	6	107%
3	III	0,00%	5	0%	7	0%	7	0%
4	IV	21,43%	9	193%	8	171%	5	107%
5	V	3,57%	6	21%	8	29%	7	25%
6	VI	14,29%	6	86%	7	100%	8	114%
7	VII	10,71%	8	86%	7	75%	6	64%
8	VIII	7,14%	6	43%	7	50%	8	57%
	Jumlah	**100,00%**	**607%**		**775%**		**725%**	
	Peringkat		**3**		**1**		**2**	

Source: Analysis, 2022

Recommendation Stage

The final stage of the value engineering process, which consists of preparing and presenting the conclusions of the value engineering analysis results. Reports prioritize facts and information to support arguments. The results of the analysis of the application of *value engineering* determined the type of work on the construction of the reservoir that could be value engineered, including:

1. Overflow work, the initial design is in the form of masonry work items 1PC: 4PP with alternative designs chosen to be K-225 Reinforced Concrete and Cyclop Concrete (A3), from an initial design fee of Rp. 5,693,832,457.09 after engineering the value of the cost to Rp. 5,497,207,098.27 there is a cost savings of Rp. 196,625,358.82 or 3.45%.
2. *Gate Valve* Homework, the initial design is in the form of masonry work items 1PC: 4PP with alternative designs chosen to be Rebate Concrete and U-Ditch 30 x 30 (B3), from an initial design fee of Rp. 2,183,572,627.64 after engineering the value of the cost to Rp. 1,541,912,231.04 there is a cost savings of Rp. 641,660,396.60 or 29.39%.
3. *Reservoir* work, the initial design was in the form of a 2.5 diameter GIP pipe work item with an alternative design chosen to be dia HDPE pipe. 2.5" (C2), from the initial design cost of Rp. 1,491,079,673.45 after engineering the cost value to Rp. 705,202,725.22 there was a cost savings of Rp. 785,876,948.23 or 52.71 %.

So that the overall construction cost of the initial design project is Rp. 17,557,422,182.35 after the application of *value engineering* with the selected alternative designs amounted to Rp.15,933,259,478.70. There is an overall saving in project construction costs of IDR 1,624,162,703.65 or 9.25% of the entire initial design cost.

Table 17
Recapitulation of Construction Cost Savings

No.	Uraian Pekerjaan	Jumlah Harga			
		Desain Awal		Value Engineering	
1	Pekerjaan Persiapan	Rp	39.042.235,24	Rp	39.042.235,24
2	Pekerjaan Tubuh Embung	Rp	4.226.745.701,67	Rp	4.226.745.701,67
3	Pekerjaan Spillway (Pelimpah)	Rp	5.693.832.457,09	Rp	5.497.207.098,27
4	Pekerjaan Intake (inlet - outlet)	Rp	1.451.317.923,03	Rp	1.451.317.923,03
5	Pekerjaan Rumah Gate Valve	Rp	2.183.572.627,64	Rp	1.541.912.231,04
6	Pekerjaan Reservoir	Rp	1.491.079.673,45	Rp	705.202.725,22
7	Pekerjaan Hidran Umum	Rp	1.383.675.256,15	Rp	1.383.675.256,15
8	Pekerjaan Bangunan Pelengkap	Rp	1.088.156.308,09	Rp	1.088.156.308,09
	Jumlah Total	**Rp**	**17.557.422.182,35**	**Rp**	**15.933.259.478,70**
	Jumlah Penghematan Biaya			**Rp**	**1.624.162.703,65**
	Prosentase Penghematan Biaya				**9,25%**

Source: Analysis, 2022

CONCLUSION

Based on the results of the application of *value engineering* in this study, the following conclusions were obtained:

- The selected construction design alternatives are 3 (three) types of work, 1) Overflow Work with Reinforced Concrete K-225 and Cyclop Concrete (A3) work items; 2) Gate Valve Homework with Rebate Concrete work items and U-Ditch 30 x 30 (B3); 3) Reservoir work with HDPE pipe work items dia. 2.5" (C2).

With the selected design alternative there is a construction cost saving of Rp.1,624,162,703.65 or 9.25% of the overall initial design cost .

REFERENCES

Amir, A., & Zakia, Z. (2018). Optimasi Biaya Pelaksanaan Konstruksi Jalan Dengan Aplikasi Rekayasa Nilai (Value Engineering). *Jurnal Teknik Sipil Dan Teknologi Konstruksi*, *1*(1).

Andriani, R. M., Sugiyarto, S., & Setyawan, A. (2019). Penerapan Value Engineering Pada Struktur Bangunan Gedung (Studi Kasus: Proyek Universitas Negeri Yogyakarta). *Matriks Teknik Sipil*, *7*(1).

Ani Firda, S. S. (2018). Penerapan Value Engineering Pada Pekerjaan Konstruksi Studi Kasus Proyek Pembangunan Rumah Sakit Umum Provinsi Sumatera Selatan: Ani Firda, Sandi Saputra. *Forum Mekanika*, *7*(2), 78–86.

Bahri, K., & Indryani, R. (2018). Penerapan Rekayasa Nilai (Value Engineering) Pekerjaan Arsitektural Pada Proyek Pembangunan Transmart Carrefour Padang. *Jurnal Teknik Its*, *7*(1), D1–D5.

Baskara, S. (2019). Rekayasa Nilai Pada Proyek Pembangunan Gedung Kantor Bps Provinsi Sulawesi Tenggara. *Jurnal Inovasi Sains Dan Teknologi (Instek)*, *2*(2), 51–62.

Bertolini, V., Wisnumurti, W., & Zacoeb, A. (2015). Aplikasi Value Engineering Pada Proyek Pembangunan Gedung (Studi Kasus Hotel Grand Banjarmasin). *Narotama Jurnal Teknik Sipil*, *1*(2).

Diputera, I. G. A., Putera, I., & Dharmayanti, G. (2018). Penerapan Value Engineering (Ve) Pada Proyek Pembangunan Taman Sari Apartement. *Jurnal Spektran*, *6*(2), 210–216.

Fisk, Z., Lambert, S. E., Maple, M. B., Remeika, J. P., Espinosa, G. P., Cooper, A. S., Barz, H., & Oseroff, S. (1982). Magnetic And Superconducting Properties Of Rare Earth Osmium Stannides. *Solid State Communications*, *41*(1), 63–67.

Julien, H. E. (1999). Barriers To Adolescents' Information Seeking For Career Decision Making. *Journal Of The American Society For Information Science*, *50*(1), 38–48.

Khamim, M., & Harsanti, W. (2015). Studi Rekayasa Nilai (Value Engineering) Perencanaan Pembangunan Gedung Perpustakaan Dan Auditorium Universitas Yudharta Pasuruan. *Prokons: Jurnal Teknik Sipil*, *9*(2), 120–129.

Mahyuddin, M. (2020). Analisa Rekayasa Nilai (Value Engineer) Pada Konstruksi Bangunan Rumah Dinas Puskesmas Karang Jati Balikpapan. *Journal Techno*

Entrepreneur Acta, *5*(1).

Putra, H. N. A., Sugiyarto, S., & Setyawan, A. (2018). Analisis Value Engineering Pada Pondasi Jembatan (Studi Kasus: Proyek Jembatan Kali Cengger Tol Semarang-Solo Ruas Salatiga-Boyolali Sesi Ampel-Boyolali). *Matriks Teknik Sipil*, *6*(4).

Retno, D., & Hastuti, H. D. (2002).\ Penerapan Studi Rekayasa Nilai Pada Perencanaan Struktur Atap Gedung Serba Guna Universitas Muhammadiyah Malang. *Jurnal Teknik Industri*, *3*(2), 121–130.

Syafira, M. A., Ardiani, W., & Putra, R. (2020). Pengaruh Work Family Conflict Dan Efikasi Diri Terhadap Pengembangan Karir Karyawan, Dimoderasi Oleh Dukungan Organisasi Pada Badan Pengelola Pajak Dan Retribusi Daerah Kota Medan. *Target: Jurnal Manajemen Bisnis*, *2*(2), 237–250.

Zimmerman, L. W., & Hart, G. D. (1982). *Value Engineering: A Practical Approach For Owners, Designers, And Contractors*. Van Nostrand Reinhold Company.