

Innovation Pipe Bridge Design for Drinking Water in Urban Areas using Value Engineering Method

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Abstract. Clean water supply in North Sulawesi Province requires infrastructure development, but there are limited government funds for building public infrastructure, so projects and investments must be determined carefully. This research aims to analyze the main river crossing distribution network using the value engineering method. The result of the study is using the horizontal drill construction of the river crossing distribution network (Horizontal Direct drilling, or HDD) as a substitute for steel frames. Based on LCCA analysis, option 2, RIVER has lower LCCA than option 1 at 3,546 billions, so option 2 is the best choice for river crossing design. This research benefits academics and practitioners who study value engineering and support the development of clean water infrastructure, especially in Eastern Indonesia.

1. Introduction

Infrastructure capacity that provides safe and suitable raw water in Indonesia is only 30% of the total national raw water needs in 2019. This condition encourages the widespread use of other sources of raw water that are not necessarily safe and proper, both in quantity and quality. Problems arise when the quality of groundwater and river water used by the community is not good enough to meet clean water standards, even in some places.

Increasing population pressure and economic activity in agglomerations and growth such as urban and strategic areas (KEK, KI, KSPN) must also be addressed to meet their raw water needs through adequate infrastructure. Based on data, infrastructure for drinking water and sanitation services in urban areas is still inadequate. The level of provision of minimal water supply in urban areas is only 51.54%, including the coverage of piped water access services, which only reaches 29.30%

In 2021, the Rispam for North Sulawesi Province will be updated, and the Bimantara Regional SPAM will be selected to serve the Bitung Regency, Manado City, and North Minahasa Regency. The total water demand (demand) in the Bimantara Regional SPAM service area (up to 2045) is 1,807 l/s, with Supply from the existing production capacity of only 345 l/s, so there is a gap of 1,463 l/s. Bimantara Regional SPAM is operated to fill the gap or deficit of drinking water in the service area of 1,500 l/s

This study will explore how the water treatment will be built through value engineering analysis. Value Engineering (VE) is a method that analyzes the problems of a project through a systematic and organized approach by eliminating unnecessary costs without reducing the project's function, appearance, quality, and reliability. Value engineering aims to achieve critical functionality at the lowest lifecycle cost consistent with the required performance, quality, reliability, and safety [1], [2]

This research has two objectives: first is to understand the functions that can be identified in Bimantara water treatment, and second is to arrange the fast diagram. Value Engineering (VE) is a team-based decision-making process that is carried out in a systematic and structured manner. Value with the lowest project life cycle costs by using alternative materials, alternatives as well as design innovations, simplifying processes to optimize efficiency, optimize time and cost, improve quality, improve safety, and minimize environmental impact [4]. VE has the advantages of offering cost efficiencies and improving project performance, better communication, and generating higher value. Implementing VE in facility management results in the optimization of company costs and risks. The results of VE show an increase in value, which presents a choice for decision-makers [5], [6]

Value Engineering is the application of a value methodology to a project or service that has been planned or conceptualized to achieve increased value. The value methodology is a systematic process used by multidisciplinary teams to increase the value of a project through an analysis of its functions. Value Engineering is a problem-solving system implemented using specific techniques, knowledge, expert teams, and creative, organized approaches that aim to identify and eliminate unnecessary Ancillary costs, such as costs that do not contribute to quality, practical life, appearance, product, and consumer attractiveness. The central concept of the Value Engineering methodology lies in value with the relationship between function and cost as follows: $(Value) = \frac{Function}{Cost}$ [3], [7]

Value engineering studies are defined as applying value engineering methods by professionals using a value job plan. The save method consists of 3 stages- the pre-workshop stage, the workshop stage, and the post-workshop stage—the value job plan, which is the procedure of the VE method.

The selected alternative drinking water pipe bridge with steel frame construction using angle iron has the same capabilities and functions as a minimal water bridge using WF iron. The principle of value engineering has been fulfilled, namely the use of cheaper materials and more straightforward work methods to be applied in PDAM Banjarnegara [8]

Value Engineering can be applied at any time throughout the project's life, from the planning to the final stages of project development. With a slight increase in project cost or value, which is around 2.5%, a more optimal function and performance of the reservoir is obtained in reservoir Semarang City [9]. In VE, analysis was carried out based on the items analyzed using the Pareto distribution. Then, further analysis was carried out with several stages/phases: information, creativity, analysis, and recommendation. The Budget Plan is grouped more concisely into several groups, and then Pareto distribution is carried out so that Value Engineering items are obtained, namely Structural Work, Wall, Floor, and Ceiling Works, as well as Channel and Road Section Works [10].

Three independent variables are the dominant factors that influence the application of value engineering, namely the implementation of infrastructure (X1), the method of using the budget (X2), and the application of value engineering (X3) to the effectiveness of using the budget (Y). Application of the value engineering method in increasing the achievement of efficiency and how to apply value engineering in the completion of main distribution [11]

Based on these studies, some previous studies discuss value engineering in construction. However, there is minimal discussion in the water treatment field. In addition, deficiencies in the research, namely discussion about VE in water treatment distribution systems in the downhill area, have not been studied

Activities at the function analysis stage determine the scope of the VE study problem, followed by identifying functions based on existing conditions (Table 1 and Figure 2).

Table 1. Function analysis

Components	Basic function	Secondary Functions	Support Functions	Functions Causes	Functions Purpose	Design Functions	Functions All Time Functions
River Crossing	Distribution of pressurized water	water Connect the hydraulic aspect Controlling pipe system	Prevent pipe leaks	Delivering through river	Carrying water Supporting	water continuity Fulfill	Water needs

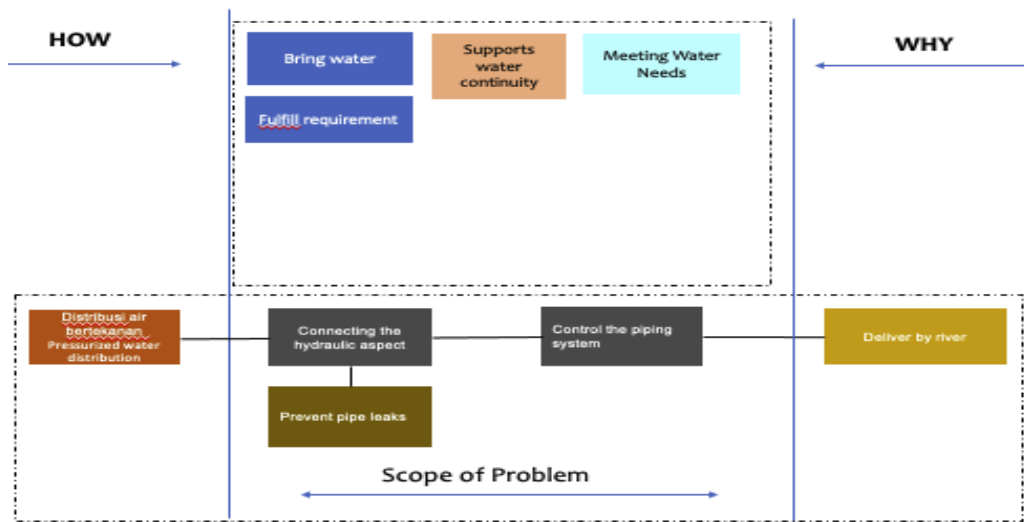


Figure 3. Fast diagram existing

c. Creative stage

The next step is creating stage. Activities at the creative stage are generating creative ideas for existing conditions. The problem with installing the river crossing bridge is that the land is on a cliff in an abutment that is prone to landslides, so a design is needed that is by the soil conditions, namely cliffs that are prone to landslides, the potential for existing at the project site. Potential and ideas obtained from horizontal drill construction (Horizontal Direct Drilling/HDD. From this idea, it was concluded that there were additional functions that were integrated into the main distribution unit river crossing function so that the diagram in Figure 3 was revised to the FAST diagram in Figure 4

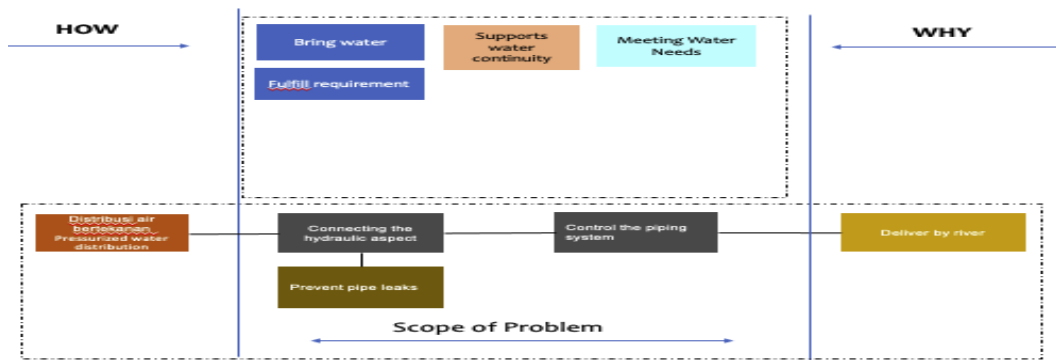


Figure 4. Fast Diagram Revised

In the creative phase, ideas have been generated that need to be evaluated. The ideas with the most potential to increase project value will be developed in the next phase, namely the development phase. At this stage the methods used are Multi Criteria Analysis (MCA) Method; Technical Evaluation; Life Cycle Cost (LCCA). Data analyzing tools is used EXCELL

1. Multi Criteria Analysis (MCA)

The MCA method can be used to assess multiple criteria, both quantitative and qualitative. Comparative analysis is used at this stage.

Table 2. Comparing matriks

Criteria	Weight					Normal Weight	Procentase (%)
	K1	K2	K3	K4	K5		
K1	1	5	5	3	3	0,43	43
K2	0,2	1	5	3	3	0,23	23
K3	0,2	0,20	1	3	3	0,14	14
K4	0,33	0,3333	0,33	1	5	0,13	13
K5	0,33	0,3333	0,33	0,20	1	0,06	6
Total	2,07	6,87	11,67	10,20	15,00	1,00	100

Table 3. MCA result

NO	Parametes	weight	Option 1		Option 2	
			Score	Value	Score	Value
1	Equipment complexity	43%	2	0,85	3	1,28083
2	Material complexity	23%	3	0,70	3	0,69906
3	Land complexity	14%	2	0,28	3	0,42344
4	Ease of implementation	13%	2	0,27	3	0,40187
5	Precipitation	6%	3	0,19	3	0,19481
Total		100%		2.30		3.00

Based on table 3, option 2 have higher value than option 1.

1. Technical evaluation

Table 4. Technical comparation option 1 and 2

Description	Option 1	Option 2
advantage	<ul style="list-style-type: none"> • Has a shorter pipe span / length • Cheaper construction costs • Smaller risk of deposition in the pipe because it is equipped with a wash out • Leaks in pipes are easier to see because the pipes are exposed 	<ul style="list-style-type: none"> • No foundation <u>work</u> • Shorter execution time • Installation costs tend to be cheaper
Disadvantage	<ul style="list-style-type: none"> • There is foundation work • Longer execution time • Installation costs tend to be more expensive for foundation structure work. 	<ul style="list-style-type: none"> • Longer stretch • There is a risk of deposition if there is no periodic maintenance • It is more difficult to detect leaks because the pipes are at the bottom

2. LCCA

LCCA is carried out to determine the right decision for the project by measuring the initial cost of work, operational costs, and maintenance. Calculation of initial capital costs, operations and maintenance. The following are several other assumptions

- Discount Rate 7,94 %
- Inflation 5,1 %
- Economic projection : 20 year

Table 5. LCCA (in Million Rupiah)

No	Description	Option 1	Option 2
1	Initial Cost	2.330	1.600
2	Operational Cost	2.037	2.037
3	Maintenance cost	339	116
4	Replacement cost	0	0
5	Residual Value	196	208
	LCCA	4.511	3.546

4. Conclusion

The functions that can be identified in Bimantara water treatment are the Basic function (Distribution of pressurized water), secondary function (water Connect the hydraulic aspect); Support function (Prevent pipe leaks), Function causes (Delivering through river), Function purpose (Carrying water Supporting); design function (water continuity Fulfill) Activities at the creative stage are generating creative ideas for existing conditions.

The problem with installing the river crossing bridge is that the land is on a cliff in an abutment that is prone to landslides, so a design is needed that is by the soil conditions, namely cliffs that are

prone to landslides, the potential for existing at the project site. Potential and ideas obtained from horizontal drill construction (Horizontal Direct Drilling/HDD. Based on LCCA analysis, option 2 has lower LCCA than option 1 at 3,546 billions, so option 2 is the best choice for river crossing design.

This research is limited to the research object in North Sulawesi. Future research should develop the results of this research to other locations that have different land contours. Thank you to Mercubuana University for funding this research

References.

- [1] M. A. Berawi, B. Susantono, H. Abdul-Rahman, M. Sari, Sesmiwati, and H. Z. Rahman, "Integrating quality management and value management methods: Creating value added for building projects," *International Journal of Technology*, vol. 4, no. 1, pp. 45–55, 2013, doi: 10.14716/ijtech.v4i1.1222.
- [2] Y. D. Suwandari and M. Mirnayani, "Evaluation of Historical Building Economic Value To Improve Company Revenue With Value Engineering Method," *Jurnal Teknik Sipil dan Perencanaan*, vol. 23, no. 1, pp. 1–8, 2021, doi: 10.15294/jtsp.v23i1.25944.
- [3] SAVE, "Value Standard," *Save*, no. June, 2007.
- [4] W. T. Chen, H. C. Merrett, S. S. Liu, N. Fauzia, and F. N. Liem, "A Decade of Value Engineering in Construction Projects," *Advances in Civil Engineering*, vol. 2022, 2022, doi: 10.1155/2022/2324277.
- [5] [5] C. Zhao, E. Yang, Y. Nie, and J. D. Russo, "Facility decision making process with modified value engineering approach," *Journal of Corporate Real Estate*, vol. 21, no. 2, pp. 112–129, 2019, doi: 10.1108/JCRE-01-2018-0002.
- [6] [6] P. Miraj, A. Dofir, A. Andreas, M. A. Berawi, and S. B. Bin Abd Karim, "Systematic Review of Value Engineering Research Studies In Indonesia," *CSID Journal of Infrastructure Development*, vol. 2, no. 2, p. 192, 2019, doi: 10.32783/csid-jid.v2i2.93.
- [7] M. A. Berawi, "Quality revolution: Leading the innovation and competitive advantages," *International Journal of Quality and Reliability Management*, vol. 21, no. 4, pp. 425–438, 2004, doi: 10.1108/02656710410530118.
- [8] Zulkifli and T. Andi, "Penerapan Value Engineering Terhadap Kierja Biaya Proyek Pemasangan Jembatan Pipa Air Minum Banjarnegara," *CESD*, vol. 3, no. 2, pp. 1–11, 2020, [Online]. Available: <https://www.ptonline.com/articles/how-to-get-better-mfi-results>
- [9] B. Satriyo, D. Lazuardi, S. G. Nugraha, and H. Budienny, "Value Engineering of Construction Design of Diponegoro Reservoir Semarang City," *ejournal3.undip.ac.id*, pp. 1–14, 2013.
- [10] U. S. Lestari, "Penerapan Value Engineering (Ve) Pada Pembangunan Gedung Kampus Ii Universitas Muhammadiyah," *Jurnal Kacapuri*, vol. 1, no. 1, pp. 102–114, 2018.
- [11] E. Khusus, "Value Engineering Pada Pembangunan Ju Akses Cibadak Di Proyek Jalan Tol," *Jurnal Sain dan Teknologi Teknik Utama*, no. 1, pp. 101–120, 2021.

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