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Analysis Of The Determination Of Bridge Foundation For Easy Field Implementation With Value Engineering Method (Case Study On The Temunih River Bridge 2, Kusan Hulu District, Tanah Bumbu Regency)

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ABSTRACT: *The design of the bridge structure has an essential role. Many factors need to be taken into consideration such as structural systems, structural materials, construction methods, site conditions and project location. The Temunih 2 Bridge, which is established in the Banjarbaru - Batulicin segment, Kusan Hulu District, Tanah Bumbu Regency, is the first step for the local government to realize the discourse on the construction of a highway connecting the city of Banjarbaru and Tanah Bumbu Regency, because the current road conditions are not yet fully integrated, so several bridges are needed. The environmental aspect where the bridge plan is established is the location where the road conditions passed to get to the work location is still many steeps, hilly incline roads and the road surface structure is still in the pavement stage. During the project development period, it is estimated that it will be challenging to mobilize tools for bridge foundation work to the project site.*

The purpose of this study was to obtain the most effective, efficient and economical type of bridge foundation and by the conditions and project location at the time of the Temunih 2 River bridge implementation by applying value engineering. This research was conducted on five respondents who are experts in the field of bridge construction. The method used is the value engineering analysis of three alternative bridge foundations, namely bore pile foundation, steel pile foundation and wells foundation. In the value engineering analysis, several stages must be carried out, namely the information stage, the creative stage, the analysis stage, the development stage and the recommendation stage.

Based on the value engineering analysis, it can be seen that of the three alternative foundations, the recommended foundation is to use a good foundation. From the results of the engineering value analysis, it was found that there was a comparison of costs as follows: the initial design cost of the bore pile foundation was Rp.1,483,066,886.85 while the recommended design costs Rp.597,753,083.65 there is a savings of Rp.885,313,803.20. Meanwhile, to save life cycle costs between the initial design of the bore pile foundation with the recommended design results of the foundation design, the life cycle cost savings of Rp.52,287,917.03 or 59.69%.

KEYWORDS: *Bridge Foundation , Value Engineering, Life Cycle Costs foundation*

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I. INTRODUCTION

Bridge is a form of construction made to connect an area, region or trajectory separately. The principle of choosing bridge construction there are several of them economical prices, implementation quickly and easily, strong and durable as well as easy and cheap maintenance. In the planning of the bridge the selection of construction type is very important because it affects the cost, method of implementation in the field and the time of implementation. Errors in the planning of a bridge can lead to increased costs, difficult field execution methods and long implementation times.

Temunih River Bridge 2 is part of the construction of Banjarbaru-Batulicin connecting road. Environmental conditions where the bridge plan is a location where the condition of the road passed to the work site there are still many steep, hilly ramps and road surface structures are still in the pavement stage. Where in the period of construction of the project is not possible in mobilizing tools for the work of the bridge foundation

to the project site. Mobilization of tools for bore pile foundation work requires large transportation which is likely to be constrained by road conditions as mentioned above. This problem will affect the time and cost of development and implementation, while on the construction of the Temunih River bridge 2 the construction is tied to the time and cost that has been determined.

With some of the above problems researchers are interested in conducting research on the bridge construction plan by looking at not allowing it to mobilize foundation work tools to the project site. To analyze the above problems and to obtain an effective, efficient and economical bridge structure, it is planned to apply value engineering to the foundation structure of the bridge.

II. LITERATURE REVIEW

The bridge has an important meaning for everyone, the bridge is part of a very important road because it connects two separate areas and the bridge as a transportation infrastructure that must meet the requirements of safe, comfortable, aesthetic, durable, easy in terms of workmanship and has an economical cost.

Foundation is the most important construction in a building, the foundation.is the bottom and directly related to the soil.

Value engineering is an evaluation method that performs technical and value analysis of a project involving owners, planners and experienced experts in their respective fields with a systematic and creative approach which aims to produce the lowest possible cost with the same quality. In value engineering analysis, there are five stages, namely the information stage, the creative stage, the analysis stage, the development stage and the recommendation stage.

III. RESEARCH METHODS

This study conducted interviews and distributed questionnaires to experts who are in the field of bridge construction. The first thing to do is the interview, this interview is intended to find out what alternative foundation information can be carried out at the construction site of Temunih River 2 bridge and also to clarify what criteria are the basis for selecting of a foundation. After the interview and get an alternative foundation that can be used then for the analysis phase of determining the assessment criteria, profit and loss analysis, feasibility level analysis and matrix analysis used questionnaire instruments by distributing questionnaires to five respondents where questionnaire questions in the form of assessment criteria such as initial costs, material procurement, implementation time, ease of implementation, strength and quality of materials, technology, facilities and labor. Respondents in this study are experts who are directly involved in the field of bridge construction such as contractors and supervisory consultants.

Data collection in the form of primary data and secondary data, where the primary data is the result of interviews and questionnaires distributed to five respondents who are in the field of bridge construction. For secondary data in the form of the image data of the design, budget plan and the location data of the bridge. In the research on this project used methods or techniques of value engineering work plan that consists of information stage, creative stage, analysis stage, development stage and recommendation stage

IV. RESULT AND DISCUSSION

4.1. RESULT

4.1.1 Information Stage

Temunih River Bridge 2 is located in Banjarbaru-Batulicin section of Kusan Hulu District of Tanah Bumbu Regency. Temunih River Bridge 2 is the object of research to determine the most effective and efficient type of bridge foundation and the most can be implemented by considering environmental conditions.

The obstacle that occurs is the environmental condition where the bridge plan is located that the condition of the road that will be passed to the work site is still in the form of dirt roads that have not been hardened and only given a layer of pavement roughing. Where during the construction of the project is not expected to allow to mobilize tools for the work of the bridge foundation to the project site.

4.1.2 Creative Stage

At this creative stage to determine creative ideas, interviews are conducted to experts in the field of bridges to find out what creative ideas for alternative foundations that can be implemented at the location of temunih 2 river bridge by looking at the condition of the field location and also by looking at the soil data. Below in Table IV.1

Table IV.1 Alternative Foundation

Alternative	Creative Ideas	Type of Material	Method of Implementation
Initial Design	Bore pile	Concrete	Non Fabrication
Alternative 1	Steel pipe piles	Steel	Fabrication
Alternative 2	Wells	Concrete	Non Fabrication

4.1.3 Analysis Stage

1. Determination of Criteria

To determine the alternative foundation that is in accordance with the objectives of this research criteria are needed as an assessment. Determination of criteria obtained from the theory then conducted interviews to experts to get clarification from the point of view of experts about the criteria considered relevant in the selection of bridge foundation structure. The criteria considered related from the point of view of experts in the criteria for choosing the bridge foundation structure are: initial cost, material procurement, implementation time, ease of implementation, strength and quality of materials, technology, working facilities and labor.

Table IV.2 Ranking of Jembatan Foundation Assessment Criteria

No	Assessment Criteria	Respondents					Total
		1	**2**	**3**	**4**	**5**	(K)
1	Initial Costs	6	7	7	7	7	34
2	Procurement of Materials	3	4	5	3	3	18
3	Ease of Implementation	7	6	6	6	5	30
4	Execution Time	5	5	4	2	6	22
5	Strength and Quality of Materials	4	2	2	1	4	13
6	Technology	2	1	1	5	2	11
7	Facilities and Manpower	1	3	3	4	1	12

Based on the table above, the values from the largest to the smallest values can be sorted from the assessment criteria for the bridge foundation structure, namely:

K_1 = Initial Costs (34)
K_2 = Ease of Implementation (30)
K_3 = Execution Time (22)
K_4 = Procurement of Materials (18)
K_5 = Strength and Quality of Materials (13)
K_6 = Facilities and Manpower (12)
K_7 = Technology (11)

2. Profit And Loss Analysis

In this analysis process the ideas are creative compared in terms of profit (+) and loss (—). Ideas for the selection of bridge foundations are obtained from measuring the foundation criteria by comparing them in terms of the advantages and disadvantages of each foundation criteria as an alternative option. For the way the questionnaire assessment experts are asked to choose between two choices between options that have advantages and have disadvantages. For options that have advantages, they are rated (+) while those who choose deficiency are rated (—).

Table IV. 3 Profit and Loss Analysis

No	**Foundation Alternatives**	**Assessment Factor to**	**Score K (a)**	**Advantages (b)**	**Score (+) (c=axb)**	**Deficiency (d)**	**Score (–) (e=axd)**	**Difference (f=c-e)**
1	Bore Pile	Initial Costs	34	1	34	4	136	
		Procurement of Materials	18	3	54	2	36	
		Ease of Implementation	30	1	30	4	120	
		Execution Time	22	0	0	5	110	
		Strength and Quality of Materials	13	5	65	0	0	
		Technology	12	5	55	0	0	
		Facilities and Manpower	11	4	48	1	12	
					286		**414**	**–128**
2	Steel pipe piles	Initial Costs	34	0	0	5	170	
		Procurement of Materials	18	0	0	5	90	
		Ease of Implementation	30	2	60	3	90	
		Execution Time	22	3	66	2	44	
		Strength and Quality of Materials	13	5	65	0	0	
		Technology	12	5	55	0	0	
		Facilities and Manpower	11	5	60	0	0	
					306		**394**	**–88**

3	Wells	Initial Costs	34	5	170	0	34	
		Procurement of Materials	18	5	90	0	18	
		Ease of Implementation	30	5	150	0	0	
		Execution Time	22	4	88	1	22	
		Strength and Quality of Materials	13	3	39	2	13	
		Technology	12	0	0	5	11	
		Facilities and Manpower	11	5	60	0	12	
					597		**103**	**494**

From Table IV. 3 Evaluated alternative ideas by choosing the most advantages that are the largest number. At this stage of analysis the alternative values of the bridge foundation are: Well foundation (+) 494 then steel pipe stake (—) 88 and bore pile (—) 128. It is then followed by a selection on the level of feasibility analysis.

3. Feasibility Level Analysis

Alternative bridge foundation options will then be analyzed in the analysis phase of the feasibility level.
Examples of calculation of feasibility level analysis for bore pile foundation with initial cost criteria are as follows:

Number of Respondents = 5 respondents
Answer with a scale/value of 1 = 0 respondents
Answer with a scale/value of 2 = 5 respondents
Answer with a scale/value of 3 = 0 respondents
Answer with a scale/value of 4 = 0 respondents
Answer with a scale/value of 5 = 0 respondents

So the average rating scale against the initial cost criteria (K1) on the bore pile foundation work is:

$$\text{Average value} = \frac{(1 \times 0)+(2 \times 5)+(3 \times 0)+(4 \times 0)+(5 \times 0)}{5} = 2$$

For other criteria are calculated in the way as calculated above and then the results are summed. Those with the highest value then indicate that they have a high feasibility value and the lowest value has a low feasibility value, as shown in Table IV.4.

Table IV.4 Eligibility Level Analysis

Eligibility Level Analysis

K_1	= Initial Costs	K_5	= Strength and Quality of Materials
K_2	= Ease of Implementation	K_6	= Facilities and Manpower
K_3	= Execution Time	K_7	= Technology
K_4	= Procurement of Materials		

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	Σ
Foundation Bore Pile	2.0	2.2	2.0	3.4	4.2	2.4	3.6	**19.8**
Foundation Steel pipe piles	1.8	2.6	2.0	1.8	4.4	3.6	3.8	**20.0**
Foundation of the Well	4.2	3.8	3.6	4.4	3.0	3.6	2.2	**24.8**

From the feasibility level analysis can be concluded that the foundation that has the highest value is the well foundation, then the foundation of the steel pipe stake and bore pile foundation.

4. Matrix Analysis

Matrix I:

Paired Comparison Matrix

	K1	K2	K3	K4	K5	K6	K7
K1	1.00	1.13	1.55	1.89	2.62	2.83	3.09
K2	0.88	1.00	1.36	1.67	2.31	2.50	2.73
K3	0.65	0.73	1.00	1.22	1.69	1.83	2.00
K4	0.53	0.60	0.82	1.00	1.38	1.50	1.64
K5	0.38	0.43	0.59	0.72	1.00	1.08	1.18
K6	0.35	0.40	0.55	0.67	0.92	1.00	1.09
K7	0.32	0.37	0.50	0.61	0.85	0.92	1.00

Matrix I	Vector
1.46	0.17
1.41	0.16
1.29	0.15
1.22	0.14
1.11	0.13
1.08	0.13
1.08	0.12
∑=**8.62**	

Matrix II:

Paired Comparison Matrix

	K1	K2	K3	K4	K5	K6	K7
K1	1.00	1.13	1.55	1.89	2.62	2.83	3.09
K2	0.88	1.00	1.36	1.67	2.31	2.50	2.73
K3	0.65	0.73	1.00	1.22	1.69	1.83	2.00
K4	0.53	0.60	0.82	1.00	1.38	1.50	1.64
K5	0.38	0.43	0.59	0.72	1.00	1.08	1.18
K6	0.35	0.40	0.55	0.67	0.92	1.00	1.09
K7	0.32	0.37	0.50	0.61	0.85	0.92	1.00

Priority	Matrix II Vector
0.17	1.92
0.16	1.70
0.15	1.24
0.14	1.02
0.13	0.74
0.13	0.68
0.12	0.62

Priority Value Matrix

Matrix II		Priority Vector		Priority Value Matrix
1.92		0.17		11.36
1.70		0.16		10.39
1.24		0.15		8.33
1.02	:	0.14	=	7.21
0.74		0.13		5.72
0.68		0.13		5.40
0.62		0.12		5.08
				∑= **53.49**

So that it is obtained:

- **λ** $= \frac{\Sigma \text{ MNP}}{n} = \frac{53.49}{7}$ = 7.64
- **CI** $= \frac{(\lambda\text{-}n)}{(n\text{-}1)} = \frac{(7.64\text{-}7)}{(7\text{-}1)}$ = 0.11
- **CR** $= \frac{CI}{RI} = \frac{0.11}{1.32}$ = 0.08 < 0,1 (consistent data)

The data from the expert team is valid (consistent). From the priority value matrix, the respective weights of the assessment criteria for the bridge foundation can be applied in the following order:

- Initial Costs = 0,17 x 100 % = 17 %
- Ease of Implementation = 0,16 x 100 % = 16 %
- Execution Time = 0,15 x 100 % = 15 %
- Procurement of Materials = 0,14 x 100 % = 14 %
- Strength and Quality of Materials = 0,13 x 100 % = 13 %
- Facilities and Manpower = 0,13 x 100 % = 13 %
- Technology = 0,12 x 100 % = 12 %

The provision of criteria value at this stage is given based on the results of the analytical hierarchy process (PHA), and for the assessment scale of the criteria is given between 1 to 4, where the value 1 = low, value 2 = reasonable, value 3 = good, value 4 = very good. After the assessment is completed and the scale of each criteria is multiplied by the weight (%) obtained from the matrix value. Then each of the criteria is summed up and for the results can be seen in Table IV.5.

Table IV.5 Matrix Analysis

K_1	= Initial Costs	K_5	= Strength and Quality of Materials
K_2	= Ease of Implementation	K_6	= Facilities and Manpower
K_3	= Execution Time	K_7	= Technology
K_4	= Procurement of Materials		

Criteria	K_1	K_2	K_3	K_4	K_5	K_6	K_7	Σ (%)
Weights are obtained from the analysis With PHA (% Value)	17	16	15	14	13	13	12	Score
Foundation Bore Pile	1.0	1.0	2.0	2.0	2.0	1.0	2.0	
	5.9	6,3	13.3	14.3	15.4	7.7	16.7	**79.5**
Foundation Steel pipe piles	1.0	1.0	2.0	2.0	2.0	2.0	2.0	
	5.9	6.3	13.3	14.3	15.4	15.4	16.7	**87.2**
Foundation of the Well	3.0	3.0	2.0	2.0	2.0	3.0	1.0	
	17.6	18.8	13.3	14.3	15.4	23.1	8.3	**110.8**

From Table IV.5 matrix analysis that has been done it appears that for the well foundation has the highest value of 110.8% followed by the foundation of the steel stake 87.2% and bore pile foundation 79.5% then the alternative with the highest value is the well foundation can be applied to the bridge Temunih River 2.

4.1.4 Development Stage

1. Initial Design

Pile bore pile Ø 800 mm, length 10 m with the quality of concert K-250 as much as 12 pieces in each abutment, drawings of bore pile foundation pieces can be seen in Figure IV.1a and the floor plan of bore pile foundation in Figure IV.1b. The cost for the bridge foundation work with bore pile foundation type costs Rp.1,483,066,886.85.

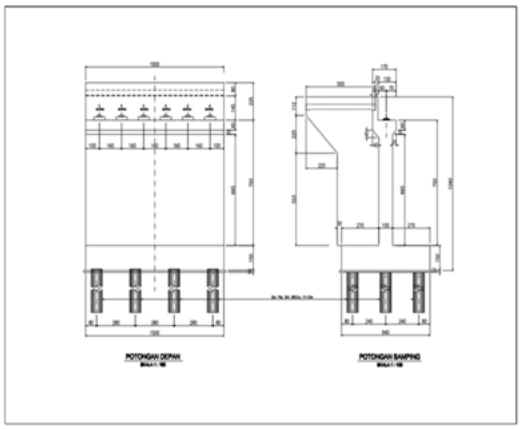

Figure IV.1a Cut of Bore Pile Foundation

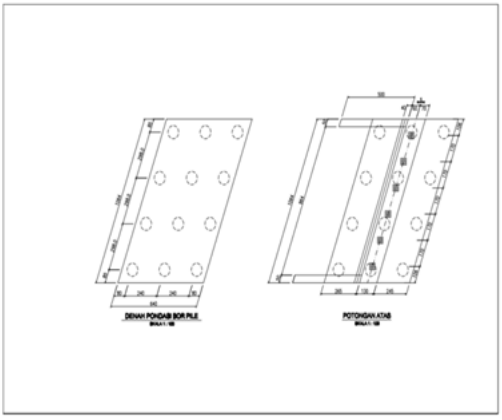

Figure IV.1b Bore Pile Foundation Plan

2. Draft Of The Selected Proposal

From the calculation of the structure, the analysis obtained the foundation of the well with Ø 400 cm long 5 m as much as 2 pieces on each abutment. At the top and bottom of the well 80 cm thick filled with waterproof concrete fc' 25 Mpa, and in the middle of the well 340 cm thick filled with cylop concrete fc' 15 Mpa, a detailed picture of the well foundation can be seen in Figure IV.2. The cost for the bridge foundation work with this type of well foundation costs Rp597,753,083.65.

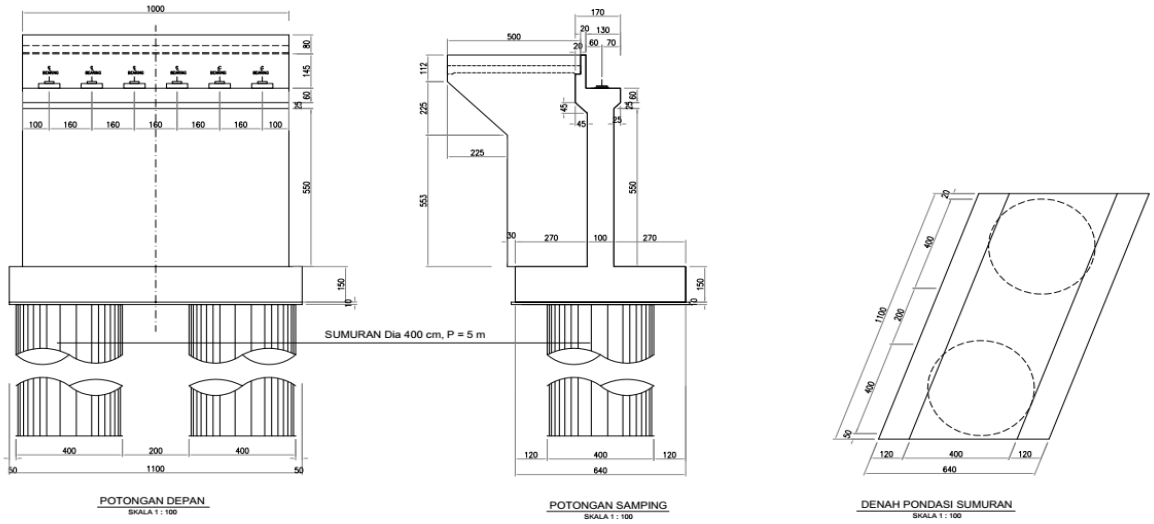

Figure IV.2 Well Foundation Design

3. Cost Comparison of Initial Draft and Draft Of Selected Proposal

The comparison of the costs of the initial design and the selected proposed design can be seen in Table IV.6.

Table IV.6 Cost Comparison of Initial Draft and Draft Of Selected Proposal

Item	Initial design (Rp)	Proposed Draft (Rp)	Difference in cost (Rp)
Foundation	1,483,066,886.85	597,753,083.65	885,313,803.20

From Table IV.6 above, there is a considerable cost difference between the initial design of bore pile foundation and the draft proposal selected well foundation where the difference in cost is Rp.885,313,803.20

4. Calculation of Life Cycle Costs

- Initial design (bore pile Ø 800 mm, 10 m long, 12 pieces)

$$= \left[\frac{0.055(1+0.055)^{50}}{(1+0.055)^{50}-1}\right] \text{ x Rp.1,483,066,886.85= Rp.87,592,080.97}$$

- Design proposal (foundation pits Ø 400 cm 5 m long, 4 pieces)

$$= \left[\frac{0.055(1+0.055)^{50}}{(1+0.055)^{50}-1}\right] \text{ x Rp.597,753,083.65 = Rp.35,304,163.94}$$

- Difference in annual life cycle costs equivalent

= Rp.87,592,080.97 – Rp.35,304,163.94
= Rp.52,287,917.03

- Difference in annual life cycle costs equivalent in percent (%)

$$= \frac{52,287,917.03}{87,592,080.97} \text{ x } 100\% = 59.69\%$$

In Table IV.7 can be seen the results of calculations for the cost of life cycle of the initial design of the bore pile foundation with the design of the selected foundation of the well foundation.

Table IV.7 Lyfe Cycle Costs

	Initial design (Rp)	Proposed Draft (Rp)
• Basic Cost		
Construction Costs	1,483,066,886.85	597,753,083.65
Total Costs	1,483,066,886.85	597,753,083.65
• Replacement cost		
No replacement for 50 years		
• Salvage cost		
There are no residual values for the foundation components		
• Operational cost		
There are no operational costs		
• Annual maintenance costs		
There are no maintenance costs		
Total Costs	1,483,066,886.85	597,753,083.65
• Total Annual Cost Equivalent	87,592,080.97	35,304,163.94
• Difference in Annual Cost Equivalent		52,287,917.03
• Percentage (%)		59.69%

4.1.5 Recommendation Stage

At this stage, it is done to provide recommendations on the results of the implementation of value engineering methods that have been implemented by recommending the selected alternatives based on the results of the analysis stage and also the development stage. The recommendations of the bridge foundation can be seen below:

1. General
2. In the study of engineering this value is a discussion is for the project foundation work items by choosing several alternative bridge foundations which must fulfill the main function of holding the load. Selection of results to obtain alternative foundations selected using value engineering methods, by having criteria namely initial cost, bridge foundation strength, implementation time, material availability, ease of implementation.
3. Design Model

The bridge foundation design is planned in accordance with the calculation results produced by planners with bina marga standard reference.

4. Analysis Tools: determination of criteria, cost-benefit analysis, feasibility analysis, matrix analysis.
5. Alternative Options: bore pile foundation, steel pipe pile foundation and foundation wells.
6. Selected alternative recommendations:

- Based on the results of the analysis that the proposed well foundation has a high value from the initial design of the bore pile foundation and the proposed foundation of steel pipe piles.
- Based on the calculation of value engineering, the selected foundation that can be proposed to be the foundation of the initial design replacement is the well foundation.
- Based on the development stage that the proposed alternative well foundation has a cheaper value than the initial design of the bore pile foundation.

7. The savings that occurred by comparing the cost of life cycle of the initial design of bore pile foundation and alternatives selected well foundation obtained savings of life cycle cost value of Rp.52,287,917.03 or 59.69%.

4.2. DISCUSSION

By applying value engineering analysis which is one of the ways to get the best alternative, effective and efficient, and has the possibility to be implemented in order to get optimal work improvement. In this discussion will be discussed about loss profit analysis system, feasibility analysis, development analysis and cost analysis of life cycle. The value engineering process provides the method used to give consideration, when setting the decision to look for the most optimal value, and also has economic value.

The alternative option that successfully passes the final evaluation is the feasibility analysis of utilization by life cycle cost method is the best alternative, which is effective, efficient and economical and has the possibility to be developed to get optimal savings or work improvement.

4.2.1 Profit And Loss Analysis

Based on the profit and loss analysis in Table IV. 3, it can be seen that the well foundation gets the highest value (+) 494 and the lowest is bore pile (—) 128. Then analyzed again at the feasibility analysis stage.

4.2.2 Feasibility Analysis

Based on this feasibility analysis, the preferred alternative is the well foundation with the highest score of 24.8. This determination is decided based on the feasibility of each alternative bridge foundation.

4.2.3 Matrix Analysis

After obtaining the results on the feasibility analysis then analyzed again using matric analysis. The result of matrix analysis is an alternative that has the highest value can be applied as an alternative foundation replacement. From the results of the analysis, it appears that the foundation alternative that has the highest value is the well foundation with a value of 110.8%. So the well foundation can be applied to temunih river bridge 2, then the results obtained will be analyzed again at the development stage.

4.2.4 Development Stage

Based on the dimensions for the selected alternatives have been selected to meet the technical requirements (strength) of the results of the calculation of the structure. In addition, it is also reviewed from the budget plan where for alternative costs the selected foundation has the lowest cost budget plan cost, in addition this determination is decided based on the feasibility of the bridge foundation with regard to the condition and location of the work, and ultimately the team of experts recommend the well foundation.

4.2.5 Lyfe Cycle Costs

In this analysis by comparing the cost of life cycle of the initial design of bore pile foundation and alternatives selected well foundation, it obtained savings of life cycle cost value of Rp.52,287,917.03 or 59.69%.

4.2.6 Impact of Value Engineering on the Initial Contract

With less work, it will have a considerable influence on the performance of the Temunih River bridge construction project 2. The effect is the change of contract (addendum), changes in the budget plan and changes to the project implementation schedule. With these changes change the value of the contract becomes reduced but does not reduce the quality of the performance of the project itself.

V. CONCLUSIONS AND SUGGESTIONS

From the description of the value engineering discussion of the Temunih 2 River bridge foundation, the following conclusions are obtained:

1. Based on profit and loss analysis, feasibility analysis and matrix analysis selected alternative foundations that have the highest value and the most likely to be implemented is the well foundation. From the result of cost calculation obtained a price comparison as follows: initial design cost for foundation work using bore pile foundation amounting to Rp.1.483.066.886.85 and for the design of the selected proposal using the well foundation of Rp.597.753.083.65. There were cost savings of Rp.885,313,803.20, and there was a life cycle cost saving of Rp.52,287,917.03 or 59.69%.
2. The impact caused by the value engineering on the initial contract is that with the change in the foundation design, the initial contract needs to be revised because it is no longer in accordance with the work to be carried out. And with these changes, it will change the value of the contract to be reduced due to the change of foundation work from the bore pile foundation to the well foundation.

The suggestions that can be given for research are:

1. For further research can be developed creative ideas by engineering the value of the structure over the bridge
2. For the selection of respondents, you can choose respondents from academics other than practitioners.

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