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Analysis of Selection of Bridge Structure with Steel Girder, Concrete Girder and Culvert Box (Case Study of SEI New Road and Bridge Construction-Kusan-Kodeco)

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ABSTRACT : *This study intends to determine the type of bridge for 11 locations points with a depth of 8-22 m and flood water level of 3-5 m. Some obstacles include the location being in the hills, access to the location is still tricky, and there is no alternative road to the location. This study aims to determine what factors are the most influential in selecting bridge structures and the type of bridge structure suitable for Sei Baru - Kusan - Kodeco, Tanah Bumbu Regency. This study uses AHP analysis. The selected respondents are competent people in the field of bridges, with 40 people consisting of the Prov. South Kalimantan, contractors, supervisory consultants, planning consultants. These respondents will assess the questionnaire given. The data from the assessment results will be analyzed into recommendations for the type of bridge structure to be implemented at the 11 bridge points. The results will be obtained in influencing factors and recommendations for the type of bridge structure. The analysis results obtained 37.100% implementation costs which have the highest value and become the main priority in determining the type of structure, 20.062% ease of implementation, 16.705% facilities, 10.826% strength and quality, 9.836% implementation time, 5.471% maintenance costs as the lowest value. The recommended type of the 9-point bridge is a non-standard box bridge, and 2 points are recommended for the implementation of a steel girder bridge.*

KEYWORDS *AHP, Bridge, Steel Girder, Concrete Girder, Non-Standard Box Culvert*

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I. INTRODUCTION

The South Kalimantan Provincial Government, especially the South Kalimantan Provincial Public Works and Spatial Planning Service, is currently building several bridges on the Sei Baru - Kusan - Kodeco section. The South Kalimantan Provincial Public Works and Spatial Planning Department often build new bridges or replaces old bridges with bridges. New Types of bridges that are often used there are 3 (three) types of bridges, including steel girders, concrete girders, or non-standard boxes. The use depends on the effective span for the standard bridge referred to in Road and Bridge Design No. 05/SE/Db/2017. In other words, it can ignore the structural analysis of each type of bridge, for the type of steel girder and concrete girder, using the manufacturing results with the size and type according to the standard. At the same time, the non-standard box is usually cast in situ because the fabrication results are only available in standard sizes. It is interesting to research what respondents who are competent and experienced in implementing the bridge need to consider in determining the type or type of bridge in terms of time, cost, ease of implementation, and quality. This will affect how much budget funds will be spent and the benefits obtained from the Public Works and Spatial Planning Office of South Kalimantan Province to build the 11 bridge points. To obtain the most efficient and effective bridge, a selection analysis will be conducted using the AHP method as a decision-making method obtained from several competent and experienced respondents in bridge implementation.

II. LITERATURE REVIEW

A bridge is a construction that is built to connect two roads that are cut off due to obstacles such as river flows, steep valleys, ravines, transverse roads, railroads, reservoirs, irrigation canals, and others. In the construction of a bridge, a strong foundation is needed to hold the entire load of the bridge to the ground. In planning a road and bridge construction, the planner must follow the rules that have been determined. One of the

regulations in the design of roads and bridges is contained in the Regulation of the Ministry of Public Works and Public Housing No. 05/SE/Db/2017 Regarding Changes in Circular Letter of the Director-General of Highways No. Um.01.03-Db/242 Regarding Submission of Design Provisions and Revision of Road and Bridge Design. In the regulation, it is explained that if it is not explicitly planned, then the building on the standard Bina Marga bridge can be used according to the economic span and water traffic conditions below it.
The data analysis method used in this research is an analysis using the statistical program SPSS (Statistical Program for Social Science). Statistical methods are divided into two consisting of the following:

1. Method Parametric Statictical
   Method Parametric Statistical method is used when the researcher knows definite facts about a group of data that is the source of the sample.
2. Method Non-Parametric Statistical
   Non-parametric statistical methods are used if the researcher does not know the characteristics of the group of items that are the source of the sample.

According to Sugiyono (2006) in Hendra (2009), the parametric method can be used if the sample to be used in the analysis from a normally distributed population, the total population or sample is above 30, and the type of data used is not nominal and ordinal data. The non-parametric method is used if the sample size is so small that the statistical distribution of the sampling cannot approach normal, and if no assumptions can be made about the shape of the distribution of the population from which the sample is sourced and when ordinal and nominal data are used. The Wilcoxon Signed-Rank Test is a sign and rating test procedure. Suppose we want to include the magnitude of the difference other than the direction of the difference in our decision-making process. In that case, the Wilcoxon signed-rank test procedure can be used (Supranto, 1988). With this, the Wilcoxon Signed-Rank Test is used as a hypothesis test to determine the comparison between the median value of the survey and the median hypothesis. With a note that it must meet the critical requirements, if it does not meet the requirements, do it again until it meets the critical requirements.

Analytical Hierarchy Process (AHP) is a decision-making method by performing pairwise comparisons between the choice criteria and pairwise comparisons between the available options. This method is a framework that simplifies and accelerates the decision-making process effectively by solving problems in a hierarchical form. This method also combines the power of feeling and logic and then synthesizes a variety of diverse considerations into results that fit our intuition intuitively on various issues (Septian, 2010). What distinguishes AHP from other decision-making models is no absolute consistency requirement. The AHP model uses the decision maker's perception as its input, so inconsistency may occur because humans have limitations in expressing their perceptions consistently, especially when comparing many criteria. Based on this condition, the decision-maker can express his perception freely without thinking about whether his perception will be consistent later or not.

III. RESEARCH METHODS

3.1 The Framework Thinking of Research

The procedure follows the framework of thinking as stated in and can be explained as follows:

1. Background
2. From the background, carry out the research's formulation, objectives, limitations, and benefits.
3. Literature review
4. Formulation of research methods
5. Hierarchical structure
6. Data Analysis

3.2 Flowchart Analytical Hierarchy Process (AHP)

Method Several stages of the Analytical Hierarchy Process (AHP) method are as follows:

1. Define the problem and determine the desired solution.
2. Create a hierarchical structure.
3. Conduct an assessment. Namely, the answers to the respondent's questions are compiled, then determine the median of the respondents' answers to each column of questions which can be referred to as the median of the survey. Then the Wilcoxon Signed-Rank test was carried out to find the median value that could be used to represent the data from the respondents' answers to each question which could be called the median hypothesis.
4. Next, enter the results from the Wilcoxon Signed-Rank Test (median hypothesis) into the paired matrix and place them according to the pairs between the factors being reviewed.
5. Form a pairwise comparison matrix that describes each element's relative contribution or influence to each goal or criterion at the level above it. Comparisons are made based on the choice or judgment of the decision-maker by assessing the level of importance of an element compared to other elements.

6. Calculate the eigenvector value and test its consistency. If it is not consistent, the data collection (preference) needs to be repeated. The eigenvector value in question is the maximum eigenvector value obtained using Matlab or manually.
7. Repeat steps 3, 4, and 5 for the entire hierarchy level.
8. Calculate the eigenvector of each pairwise comparison matrix. The eigenvector value is the value of each element. This step is to synthesize options in prioritizing elements at the lowest hierarchical level until achieving goals.
9. Test the consistency of the hierarchy. If it does not meet the CR <0.1, the assessment must be repeated until it meets the hierarchical consistency requirements.

In making the hierarchical structure, a conceptual approach is introduced to determine the selection of the bridge structure using the Analytical Hierarchy Process (AHP) method. In the model proposed in this study, there are three hierarchical levels as follows:

a. Level 1: At the first level, it explains the objectives of the decisions to be taken which will be placed at the top of the hierarchy and is also the main goal of this research, namely the selection of the type of bridge.
b. Level 2: In this second level, it is divided into six choices. Based on the criteria in terms of implementation costs, time, convenience, strength and quality, maintenance costs, and facilities. This is a factor that is considered in selecting the type of bridge.
c. Level 3/Alternative: At this level, alternative types of bridge construction are proposed that can be applied to several bridges on the Sei Baru - Kusan - Kodeco section of South Kalimantan namely Steel Girder, Concrete Girder, and Non-Standard Box.

This study uses level 2 in the AHP hierarchical structure. The alternative type of structure selection is based on several factors such as implementation costs, implementation time, ease of implementation, strength and quality, cost and maintenance, and facilities. After the Analytical Hierarchy Process (AHP) hierarchical structure is created, the next step is to determine the assessment of priority elements at each level. For this reason, a comparison matrix is needed, which contains the condition of each element which is described in the quantitative form in the form of numbers indicating the rating scale (1–9).

The assessment results of respondents' answers to each question can then be formed into a matrix. The matrix formation is carried out for each group of questions according to the number of questions in each group, as described in the previous section. The assessment results in the previous section are entered in the cells above the diagonal. The diagonal cell will be filled with the number 1. At the same time, the other cells will be filled with the inverse number according to the pair of like cells.

Each matrix will produce a weighting at each level. The value of each level will be input for the next level until the final weighting is obtained. If the CR is greater than the acceptable value, then the Analytical Hierarchy Process (AHP) method needs to be repeated because the evaluation in the matrix is less consistent. If the CR value is lower or equal to that value, it can be said that the assessment in the matrix is quite acceptable, or the matrix has a good consistency.

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3.3 Grouping of Factors from Previous Research

There are 7 (seven) groups of factors from 104 (one hundred and four) factors based on previous research and laws and regulations. The group of factors are:

1. Factor Amount of Offer
2. Bid Evaluation Factor
3. Self-Estimated Price Factor
4. Error Factors In Document Selection
5. Disclaimer Factor
6. Factors of Corruption, Collusion and Nepotism
7. Factors of Electronic Procurement System

IV. ANALYSIS AND DISCUSSION

4.1 Identification of Respondents

Based on the results of the questionnaire survey, it is known that from a total of 40 respondents, most of the respondents have a master's degree education background, which is 30% (12 people), 70% (28 people) of the respondents have an undergraduate education background can be seen in Figure 1.

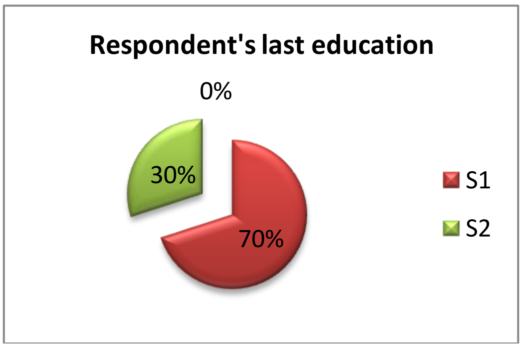

Figure 1. Last Educational Background

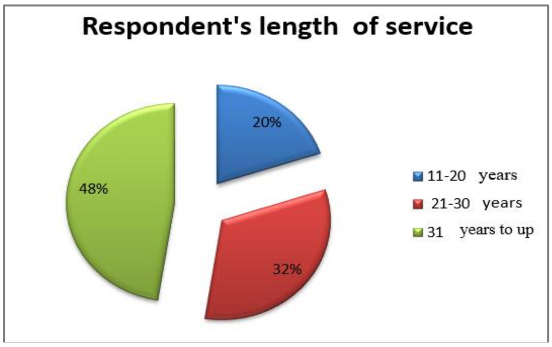

Figure 2. Respondent's Work Experience

Based on the results of the questionnaire survey, it is known that from a total of 40 respondents, most of the respondents have experience working in the construction sector for 31 years and over 48% (19 people), 32% (13 people) respondents have 21-30 years of experience, and 20% (8 people) of respondents with 11-20 years of experience in the bridge sector. It can be seen in Figure 2.

4.2 Determination of Dominant Criteria

Table 1. Wilcoxon test results for questions 1-15

No.	Questions		Survey		Hipotesis	
	Original	Against	Median	p-value	Assumed	p-value
1	Implementation Cost	Time	4	0,243	4	0,243
2	Implementation Cost	Ease of Implementation	3	0,346	3	0,346
3	Implementation Cost	Strength and Quality	4	0,039	3	0,116
4	Implementation Cost	Cost Maintenance Cost	5	0,232	5	0,232
5	Implementation Cost	Facility	2	0,711	2	0,711
6	Implementation Time	Ease of Implementation	-4	0,003	-3	0,51
7	Implementation Time	Strength and Quality	2	0,943	2	0,943
8	Implementation Time	Maintenance Cost	4	0,011	3	0,23
9	Implementation Time	Facility	-4	0,382	-4	0,382
10	Ease of Implementation	Strength and Quality	3	0,673	3	0,673
11	Ease of Implementation	of Maintenance Cost	4	0,019	3	0,11
12	Ease of Implementation	Facility	1	0,711	1	0,711
13	Strength and Quality	of Maintenance Cost	2	0,091	2	0,091
14	Strength and Quality	Facility	2	0,096	2	0,096
15	Maintenance Cost	Facility	-3	0,226	-3	0,226

In Table 1, it can be seen in number 3 that the cost of implementation with strength and quality has shifted in value from 4 (four) to 3 (three) because the p-value is 0.039 <0.05, it does not meet the requirements so that it shifts to 3 (three) with a p-value of 0.116 fulfilling the p-value > 0.05. Furthermore, the same treatment on questions number 6, 8 and 11 which shifts the value.

The determination of the eigen value is the result of multiplying the 6x6 matrix of the hypothetical median number against the weights, the results of the eigen value can be used to determine the consistency index for calculating the consistency ratio value. The matrix can be seen in Table 2.

Table 2. Wilcoxon test results for questions 1-15

	Coast	Time	Convenience	Strength	Low Cost	Means
Coast	1	4	3	3	5	2
Time	1/4	1	1/3	2	3	1/4
Convenience	1/3	3	1	3	3	1

Strength	1/3	1/2	1/3	1	2	2
Low Cost	1/5	1/3	1/3	½	1	1/3
Means	1/2	4	1	½	3	1

Table 3. Determination of Cr Value of 6x6 Matrix for questions 1-15

	Coast	Time	Convenience	Strength	Low Cost	Means	MG	Weight	Eigenvalue
Coast	1	4	3	3	5	2	2,667	0,371	2,299
Time	¼	1	1/3	2	3	1/4	0,707	0,098	0,680
Convenience	1/3	3	1	3	3	1	1,442	0,201	1,275
Strength	1/3	1/2	1/3	1	2	2	0,778	0,108	0,792
Low Cost	1/5	1/3	1/3	½	1	1/3	0,393	0,055	0,338
Means	1/2	4	1	½	3	1	1,201	0,167	1,165
						Total	7,189	1,000	6,549

Ci = 0.110; Ri = 1,240; Cr = 8.858%; Cr < 10% (accepted)

The value of Cr is 8.858% <10%. This indicates that the results of the calculation of the consistency ratio from questions 1 to 15 are acceptable. Based on the above data, it is known that the 37.100% implementation cost criteria have the highest value and become the main priority in determining the type of bridge, the ease of implementation criteria is 20.062%, the facilities criteria are 16.705%, the strength and quality criteria are 10.826%, the implementation time criterion is 9.836%, the maintenance cost criteria is 5,471 % as the lowest value.

4.3 Bridge Construction Selection Assessment Bridge

The following is a recapitulation of the results of the assessment of the selection of bridge construction in this study as follows.

Bridge point 1: non-standard box
Bridge point 2: non-standard box
Bridge point 3: non-standard box
Bridge point 4: non-standard box
Bridge point 5: non-standard box
Bridge point 6: non-standard box
Bridge point 7: non-standard box
Bridge point 8: non-standard box
Bridge point 9: steel girder
Bridge point 10: steel girder
Bridge point 11: non-standard box

4.4 Determination of The Bridge Construction

The results of the final weighting obtained for the type of construction on 11 bridges can be seen in Table 4.

Table 4. The results of determining the type of bridge for 11 bridges

NO	SPREAD SEGMENT	LENGTH (M)	DEPTH (M)	FLOOD FACE FROM THE TOP EDGE OF THE RIVER	BRIDGE TYPE
1	SP4. PENGARON KM.17 - SP4. DS. SUMBER BARU	9,6	-3,9	-1,0	Box non standard
2	SP4. DS. SUMBER BARU - SP3. KAHELAAN	9,1	-1,2	1,2	Box non standard
3	SP4. DS. SUMBER BARU - SP3. KAHELAAN	11,1	-4,0	-2,0	Non-standard box
4	SP4. DS. SUMBER BARU - SP3. KAHELAAN	8,7	-4,3	-2,0	Non-standard box
5	SP4. DS. SUMBER BARU - SP3. KAHELAAN	10,0	-1,4	1,4	Non-standard box
6	SP4. DS. SUMBER BARU - SP3. KAHELAAN	10,0	-3,0	-0,3	Non-standard box
7	SP4. DS. SUMBER BARU - SP3. KAHELAAN	9,0	-3,0	0,4	Non-standard box
8	SP4. DS. SUMBER BARU - SP3. KAHELAAN	11,0	-3,0	0,2	Non-standard box

NO	SPREAD SEGMENT	LENGTH (M)	DEPTH (M)	FLOOD FACE FROM THE TOP EDGE OF THE RIVER	BRIDGE TYPE
9	SP4. DS. SUMBER BARU - SP3. KAHELAAN	20,0	-4,4	-1,5	Steel Girder
10	SP4. DS. SUMBER BARU - SP3. KAHELAAN	22,0	-1,8	1,3	Steel Girder
11	SP4. DS. SUMBER BARU - SP3. KAHELAAN	8,5	-1,5	0,2	Non-standar box

From the questionnaire results, respondents' assessment at 11 points of the Sei Baru - Kusan - Kodeco Bridge, Tanah Bumbu Regency for the service, contractors, and consultants who then processed the data using the AHP method, priorities or recommendations were obtained for each bridge. Nine points include the implementation of a non-standard box bridge, while at point 9 and point ten bridges after the survey. Also, because the span at the bridge point is more than 20 meters, it is recommended to implement a steel girder bridge.

V. CONCLUSION

Based on the above discussion regarding the selection of bridge structures with steel girders, concrete girders, and non-standard boxes (a case study of the construction of roads and bridges of Sei Baru - Kusan - Kodeco) Prov. South Kalimantan conclusions can be drawn as follows:

1. Factors in determining the bridge's structure include implementation costs, implementation time, ease of implementation, strength and quality, maintenance costs, and facilities.
2. From the results of the weighting of the 37.100% implementation cost criteria, which has the highest value and becomes the main priority in determining the type of bridge, the ease of implementation criteria is 20.062%, the facilities criteria are 16.705%, the strength and quality criteria are 10.826%, the implementation time criterion is 9.836%, the maintenance cost criteria is 5.471% as the lowest value.
3. From the final results of a bridge with a span of 8-12 m, respondents prefer implementing a non-standard box bridge, while respondents prefer a steel girder bridge at a span of 22 m.
4. The implementation time will affect each point because it has to go through the last bridge that is still being implemented. There are no other accesses or other intersections at that location. With a not-so-long span, it is recommended for non-standard boxes with economic dimensions, and for a reasonably long span, it is recommended for steel girders rather than concrete girders, judging from the location, condition, and facilities at Sei Baru - Kusan - Kodeco Tanah Bumbu Regency.

Suggestion

As for suggestions that can be given for further research are:

1. To work on bridge points 9 and 10, the work on the previous bridge points must be completed and can be passed by heavy traffic so that the mobilization of the steel girder can be carried out.
2. It is necessary to increase the number of respondents with more comprehensive sources involving experts for data using the AHP method.
3. It is hoped that the procedures for approaching the respondents (experts) are carried out properly so that data can be obtained both verbally and in writing (questionnaires) correctly and completely.
4. It is hoped that further research will be carried out so that the factors reviewed are broader. An example is by adding an environmental impact analysis (AMDAL) to construction work and analyzing the application of Occupational Safety and Health in construction projects.

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