RISK OF BRIDGE CONSTRUCTION USING THE PROMETHEE METHOD IN PAPUA

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Abstract

the form of questionnaires and interviews were conducted at four construction service companies in Jayapura. Risk analysis is carried out by looking for values that represent respondents' answers using the Sevirity Index (SI) method and the Risk Breakdown Structure (RBS) method to get the highest level of risk. Furthermore, analyze the risk using the (PROMETHEE) method to get the ranking of the most important risks.. So that nine indicators are obtained that affect cost performance with a high risk scale, namely culture and customs of the surrounding community, material price increases, material unavailability, delays in material delivery from suppliers, unstable soil conditions, delays in equipment delivery, design / specification changes, incomplete designs, disputes and claims. as a conclusion from the results obtained, it is found that the highest risk ranking for time and cost performance is the culture and customs of the surrounding community.

Papua's topography is very diverse in the form of mountains, tropical rainforests. Papua has difficult access constraints and between regions that can only be reached by using air transportation modes, so Papua is in dire need of road and bridge infrastructure development so that community access in activities to meet needs and the transportation process from one location to another can run more smoothly. The research objectives are to identify risks to cost and time, analyze the dominant level of risk to cost and time in bridge construction. Data collection in

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Introduction:-

The development of projects in the construction sector in which there are many risks stemming from uncertainties from both internal and external risks that have positive and negative impact value (Wayangkau & Admojo, 2021). Risk can be an obstacle that causes delays because it affects the success of achieving the project objectives of time, cost and quality which are interrelated with each other(Sugiyono, 2016; Supriyadi & Muntohar, 2007; Y. Tang et al., 2020). There are many obstacles and obstacles in carrying out work, especially by service providers in carrying out bridge construction. Gray and Larson in (Siswanto, 1999). However, it needs to be reviewed in terms of quality, quality bridge construction or not. Not just a matter of construction but functionalization. So that the principle of expediency can be properly proportioned (Simanjuntak et al., 2022)

This research was conducted in Papua, Papua is the outermost province located on the eastern side of the Unitary State of the Republic of Indonesia Papua's very diverse topography in the form of mountains, unspoiled tropical rainforests and beaches makes Papua have difficult access problems and between regions that can only be reached using air transportation, so Papua is in dire need of road and bridge infrastructure development

The purpose of this research is:

- Identify the charatecteristic of risk in bridge construction project in Papua, and
- Analyze the dominant level of risk with PROMETHEE methode in bridge construction in Papua

Literature Review:-

Definition of risk

Every organizational activity, regardless of its type and size, will inevitably face various factors both internal and external and various kinds of influence that make them less sure how and when they can achieve organizational goals. The impact of uncertainty in achieving organizational goals is “risk”. Risks on construction projects are grouped into two categories, namely internal and external risk categories (Samudra et al., 2023). Internal risk is a risk associated with uncertainty originating from all parties involved in the project while external risk is all related things such as changes in circumstances outside the project that cannot be controlled by the parties involved in the project (Rusim et al., 2019; Samudra et al., 2023).

Definition of risk Management

Base on ISO 31000:2018 Risk Management, Risk management processes are systematically implemented in policies, procedure and practice relating to risk communication and consultation activity, determine the scope, context and criteria of risks, conduct risk assessment stages comprising risk identify, risk analyze, and risk evaluate, risk treatment, monitor and review, record and report.

Risk in Construction Activities

Construction risks in general are events that affect the project objective of cost, time, and the qualities. At each stage of the projects, there are various risks and uncertainties that affect both quality and quantity(Peckiene et al., 2013). Risk in construction activities means an activity in which there is a loss in time, cost, quality and occupational safety and health management system, due to a mismatch between the work plan and the results agreed in the contract

Project Management Stages

According to (Norken et al., 2012) Risk Management in a project must fulfill the stages. The implementation of the stages in risk management must be carried out conceptually following detailed and systematic procedures, and needs to be carried out with communication and cooperation in order to provide target accuracy in identifying risks in order to achieve work objectives that meet time, quality and cost. These include:

1. Identified
2. Analysis
3. Evaluations
4. Responses
5. Mitigation

Sevirity Index

The process of analysing the level of risk to analyse the data in this research is carried out on the assessing the probability and impact of risks on the aspects of cost and time on the construction project of Landslide Bridges 1 and 2. This analysis uses the Sevirity Index (SI) method. Where SI has the advantages of simplifying classification (PMBOK, 2017). The equation for the SI method can be seen in equation 1

$$SI = \frac{\sum_i^4 a_i x_i}{4 \sum_i^4 x_i}(100\%) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)

PROMETHEE is a method to determine the most influential risks to a project. Promethee prioritizes the use of predictive values for dominance criteria in outranking relationships. The advantage of the Promethee method is that this method is easier to understand than other decision-making methods, not only that the Promethee method also has ease in terms of weighting (Wayangkau & Admojo, 2021). Then also explained by (Rusim et al., 2019)The PROMETHEE methods are used to decide which risks have the most impact on the project. PROMETHEE is a prediction method that prioritizes the use of predicted values for criterion domination in a ranking relationship

Bridges Definations

A bridges is a structure that enables a roads to cross rivers / waterways, valleys or cross other roads with unequal surfaces. In planning and design of bridges, it should be considered the functions of transport needs, technical and aesthetic-architectural requirement which include: Traffic aspect, technical Aspect, aesthetical Aspect (Supriyadi & Muntohar, 2007)

Bridges Classications

According to (Siswanto, 1999) bridges can be classified into various types according to function, existence, materials used, type of vehicle floor and others as follows: Bridge Judging from the Materials Used

1. Wooden
2. Steel
3. Concrete
4. Prestressed Concrete
5. Composite
6. Bamboo
7. Brick

Materials and Methods:-

Research Sites

This research, there are several points of bridge locations that are the focus of research and as a source of primary data, this location was chosen because bridge projects are most often late, due to difficult geographical conditions. this bridge project is one of the national strategic projects, because it is used to connect between regions in Papua, in order to open access to remote areas so that it can reduce price disparities, both food prices and other prices, which have been very expensive compared to other regions in Indonesia. what is unique is that there is customary land ownership by indigenous Papuans through which bridge construction passes so that it becomes one of the risk factors that make bridge projects late.

1. Yetti-Senggi-Mamberamo (MYC) Bridge Section 2020-2022
2. Kali Buaya Bridge Replacement (2017, 2018, 2019)
3. Sawitami V Bridge Periodic Maintenance (2019-2020)
4. Replacement of Avalanche Bridge I and II (2021-2022)

Data Source

The data source is an important point in research, because it will provide value and quality to the research if the data can be accounted for. so determining and collecting data is very important in research to reach conclusions.

1. Primary Data
2. Secondary Data

Research Variables

In this research process, variables were identified that were obtained from conditions that occurred in the field and from previous literature, these variables were:

Table 1. Research Variables

LEVEL 0	LEVEL 1		LEVEL 2		LEVEL 3
	Source of Risk		Sub Source of Risk		Variables of Risk
Implementation Risk	A	External Predictable	I	Ground Conditions	Differences in subgrade conditions
					Unstable soil conditions
			II	Accidents	Accidents and injuries
					Difficult site location conditions
			III	Material	Material price Increase
					Unavailibility of materials
					Lack of material storage
					Delays in material delivery from suppliers
					Waste Material
Implementation Risk	B	External Unpredictable	I	Government Policy	Unstable government policy
					Monotery instability

					Permit delays
		II	There is Local Culture	Demonstration / Riot	
Implementation Risk				Sabotage	
				Labor strike	
				Culture and customs of the surrounding community	
		III	State of the project enviroment	Fragment or parts of material that fall into the river	
				Dust causes when transporting steel materials	
				Resource management and productivity	
	C	Internal non technical	I	Management	Lack of communication between contractor, consultant, and owner
					Poor management and oversight
					Lack of supervision of subcontractors and suppliers
					Lack of control over the work implementation schedule

					Lack of Contractor experience
Implementation Risk	D	Technical	I	Human/ Workforce	Kurangnya jumlah tenaga kerja Kurangnya Kemampuan dan Pengalaman Lack of Labor Avaibility of Labor Human Error
			II	Equipment	Misplacement of equipment Delay in equipment delivery Equipment Failure
			III	Methods or ways of working	Adanya perubahan desain/spesifikasi Incomplete design Structural demage Demage in pile installation Incorrect and problematic pilling points Presence of broken piles Groundwater overflow Wind and Wave effect Disputes and claims

E	Legal	I	Physical	Verification of incorrect documents

Source: Primary Data Analysis, 2024

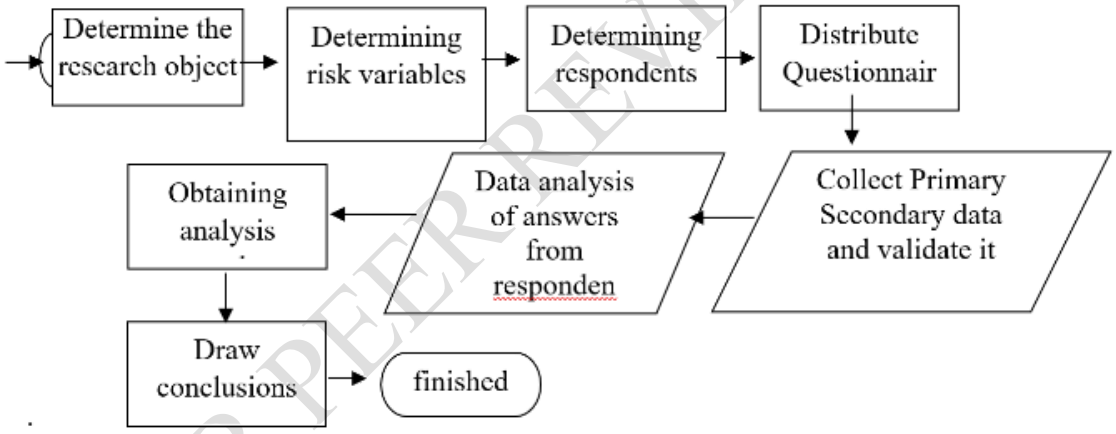
Method of Collection Data

The method of collecting data, both primary and secondary data, is the key to success in research, this is because data is the core of the objectives and achieving conclusions from research. In this research, researchers used several data collection methods, namely:

1. Observation, Direct observation at the research location to obtain all details of activities, field conditions, activity information and all information that can be used as a reference for decision making
2. Interview, Interviews in this research will be carried out directly with respondents, and also as validation of answers.
3. Questionnaire, according to (Sugiyono, 2016), a questionnaire is one of the data collection techniques carried out by providing a set of questions or statements in writing to respondents for answers. as for the analysis is done by means of statistical processing
4. Study literature, Data collection in this method is carried out by taking various sources such as books, scientific works, documented information or news so that the research has a reliable theoretical basis. This data collection can be categorized as secondary data.

Research Flowchart

Fig. 1 Research Flowchart



The description of the stages of the research flow chart is outlined as follows:

1. Start

The initial process or activity in raising ideas and determining a research topic.

2. Literature Study

The study is a data collection process carried out by reading reference books or literature, journals, online and offline information and previous research related to this research plan.

3. Problem Formulation

The process within the scope of research to summarize or find out what problems occur, so that researchers can formulate several problems to be known.

4. Research Data Collection

The data collection process in this study is grouped into two groups of data, namely:

a. Primary data consists of questionnaires and interviews

A questionnaire is a list of questions sent to respondents either directly or indirectly. The questionnaire can be in the form of questions or statements that can be answered according to the questionnaire instructions. Closed questionnaires can be answered by putting a check list mark (√) in the column, open questionnaires, can be answered by filling in the answers in the available column. Interview is the process of collection research data by mean of question and answer, directly the interviewer with the ansewere of respondent

b. Secondary data is taken from literature studies

5. Data Processing
   The results of primary and secondary data collection have been achieved or fulfilled will continue with data processing. The data processed is in the form of questionnaire data that has been distributed and then analyzing the data using the Risk Breakdown Structure (RBS) method and the severity index (SI) concept.
6. Discussion
   After obtaining the results of data processing, a detailed discussion can be carried out to determine and mitigate the research results
7. If the results of the discussion are found to be invalid (No), data checking and data analysis are carried out again.
8. After the results of data inspection and data analysis results show valid results (Yes), then proceed to the next stage, namely risk mitigation.
9. Risk Mitigation
   After discussing the results of data processing data processing and knowing the risks that may or have occurred, the next stage can determine the risk mitigation.
10. Conclusion and Suggestion
    A conclusion that can be drawn from the research results as well as suggestions and input for practitioners or academics who will conduct similar research or continue previous research.
11. Finish

Results and Discussion:-

Samples

This research takes data in the form of questionnaires distributed to service providers who handle bridge construction projects in Papua, especially, Jayapura City, Jayapura Regency, Keerom Regency. The following is a list of parties from service providers who became the research sample

Table 2. Research Samples

No	Contractor	Project
1.	PT. Anugerah Karya Agra Sentosa, PT. Sentral Multikon Indi, PT. Papua Karya Mandiri (KSO)	Avalanche Bridge 1and 2 (MYC)
2.	PT. Konsorindo Inscription Image	Replacement of the Yetti-Senggi-Mamberamo (MYC) Bridge
3.	PT. Sinabung	Replacement of the Kali Buaya Bridge (Stages 1, 2 and 3)
4.	PT. Atira Timur Mighty	Sawitami V Bridge Periodic Maintenance

Respondent Profile

The questionnaire was given to respondents who played a direct role in the implementation of the work which had the greatest responsibility in the project and also the qualifications related to the project under study, so that these respondents knew about the risks that often occurred at the job site. The respondents who helped in this study based on table 3 are directors, project managers, field managers, and executors from 4 contractor companies carrying out bridge work from 2017 to 2022

Table 3. Respondent Profile

No	Contractor	Respondent
1.	PT. Anugerah Karya Agra Sentosa, PT. Sentral Multikon Indi, PT. Papua Karya Mandiri (KSO)	*Project Manager* Executor
2.	PT. Konsorindo Inscription Image	*Site Manager* Executor (2)
3.	PT. Sinabung	Director *Project Manager* Executor
4.	PT. Atira Timur Mighty	*Site Manager* Executor

Risk Characteristic

Below are the risk variables obtained from the results of interviews with respondents regarding risk identification coupled with the author's initial ideas about the risks that might occur. From all the interview results regarding risk identification, the results will be made into a questionnaire to measure the level of risk importance, and continued by classifying risks using the risk breakdown structure method as in Table 4.

Table 4. Risk Breakdown Structure

LEVEL 0	Level 1 Sources of Risk		Level 2 Sub Source of Risk		Level 3 Indicator
Implementation Risk	A	*External Predictable*	I	Soil condition	Differences in basic soil conditions Unstable ground conditions
			II	Accident	Accidents and Injuries Difficult site location conditions
			III	Material	Increase in material prices Unavailability of materials Lack of material storage space delays in delivery of materials from suppliers Waste Materials
	B	*External Unpredictable*	I	government policy	Unstable government policies Monoteric Instability Delay in licensing
			II	Local Cultural Customs	Demonstrations/riots Sabotage Strike Culture and customs of the surrounding community
			III	The state of the project environment	Debris/parts of materials that fall into a stream Dust generated when hauling steel materials Dust caused when transporting steel materials Damage to the Surrounding Environment Resource management and

					productivity
	C	*Non-technical internals*	I	Management	Lack of communication between contractors and consultants and owners
					Poor management and supervision
					Lack of supervision of subcontractors and suppliers
Implementation Risk					Lack of control over the work implementation schedule
					Lack of contractor experience
					Lack of workforce
	D	*Technical*	I	Human/Labor	Lack of Ability and Experience
					Lack of working hours availability of labor
					Human error
			II	Equipment	Equipment Placement Errors
					Delay in Equipment Delivery
					Equipment Failure
			III	Method or way of working	There is a change in design/specification
					Incomplete design
					Structural Damage
					Damage in installing piles
					Improper and problematic stake points
					There are broken/broken piles
					Overflow of ground water
					Effect of Wind and Waves
					Disputes and claims
	E	*Legal*	I	Physique	Incorrect Document Verification

Risk Level

1. Probability assessment of risk on performance

The probability and impact rating scale according to is as follows scale ranges from very low to very high, with values from 0 to 100 The risk scale assessment according to was used to conduct a probability analysis in this study with a frequency scale of the largest project risk occurrence of 100 (Majid MZ & R, 1997)

For example, based on the results of the questionnaire obtained from the respondents' assessment of the probability of risk occurrence in the subgrade condition risk variable, namely 1 respondent stated the probability of occurrence was “Very Low” (SR), 3 respondents stated the probability was “Low” (R), 3 respondents stated the probability was “Medium” (S), 1 respondent stated the probability was “High” (T) and 2 respondents stated the probability was “Very High” (ST), the Sevirity index (SI) value was obtained:

$$SI = \frac{\{(0 \times 1) + (1 \times 3) + (2 \times 3) + (3 \times 1) + (4 \times 2)\}}{4 \times 10} \times (100\%)$$

SI= 50.00%

Description:

ai = assessment constant

xi = frequency of respondents

i = 0, 1, 2, 3, 4, ..., n

x0, x1, x2, x3, x4, are the respondent frequency responses

a0 = 0, a1 = 1, a2 = 2, a3 = 3, a4 = 4

x0 = respondent frequency "very low", then a0 = 0

x1 = frequency of respondents "low", then a1 = 1

x2 = frequency of respondents "quite high", then a2 = 2
x3 = frequency of respondents "high", then a3 = 3
x4 = the frequency of respondents "very high", then a4 = 4
The Sevirity index value is 50.00%, so the The probabilities of the subgrade condition risk variable are Medium (S). The calculation for the impact assessment on cost and time also uses the same method as above

2. Assessment of risk impact on performance

The criterion for determining the scale of impact on costs is done according to Knight and Fayek in 2002, with a scale of impact on costs:

Very Low (SR) = 1% ≤ Cost Overruns < 1.5%
Low (R) = 1.5% ≤ Cost Overruns < 2.5%
Medium (S) = 2.5% ≤ Cost Overruns < 3.5%
High (T) = 3.5% ≤ Cost Overruns < 4.5%
Very High (ST) = 4.5% ≤ Cost Overruns < 5%

For examples, the risk variable of different subgrade conditions, 1 respondent answers the risk is very low, 2 people answers medium, 3 respondents answered the risk was high and 4 respondents answered the risk was very high, then the Sevirity index value was obtained as follows:

$$SI = \frac{\{(0 \times 1) + (1 \times 0) + (2 \times 2) + (3 \times 3) + (4 \times 4)\}}{4 \times 10} \times (100\%)$$

SI= 72.5%

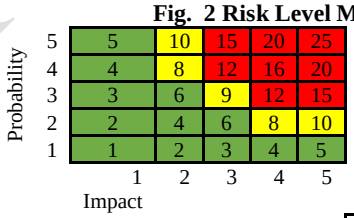
Description:
ai = assessment constant
xi = frequency of respondents
i = 0, 1, 2, 3, 4, ..., n
x0, x1, x2, x3, x4, are the respondent frequency responses
a0 = 0, a1 = 1, a2 = 2, a3 = 3, a4 = 4
x0 = respondent frequency "very low", then a0 = 0
x1 = frequency of respondents "low", then a1 = 1
x2 = frequency of respondents "quite high", then a2 = 2
x3 = frequency of respondents "high", then a3 = 3
x4 = the frequency of respondents "very high", then a4 = 4

Based on the above calculation, the value of Sevirity index (SI) = 72.50%, so the risk of differences in soil conditions is included in the "High" category.

3. Risk Level Assessment

The performance risk scale determination in this research is based on [11], as a scale of probability of respondents' assessments of job implementations. With the Categorization of risk levels ranging from low (R), medium (S), high (T), the level of cost and performance risk can be seen in Figure 2 as below:

Fig. 2 Risk Level Matrix



Score	Risk
1-6	Low
7-10	Currently
11-25	High

This analyze is used to assess the risk level of cost and time performances. Examples of calculations of cost performance risk levels by using the probability and impact multiplication can be seen as below:

For example, if the probability of the risk variable for differences in subgrade conditions is obtained with a probability value of 3 and an impact value of 4, then the value of the performance risk level is:

Risk Level = Probability x Impact

= 3 x 4 =12

From the results of the calculation of the risk level, it is then grouped according to the category, so that the value of the performance risk level of 12 is included in the "High" category According to the analyze result there is 1 risk variable with the highest risk scale against cost performance with a risk scale value of 20 and 3 risk variables with a risk scale value of 16 where the risk is includes in the "High" risk category, then on time performance there is 1 risk variable with the highest risk scale with a risk scale value of 20 and 3 risk variables with a risk scale value of 16 the risk is includes in the "High" risk category.

4. Ranking the highest risk using promethee method

After obtaining the highest risk, continue the analysis to determine the level of risk among high risks using the PROMETHEE method. The highest risk from the results of the analysis using the previous method is analyzed again by giving the results of the previous analysis to respondents to determine the value of the risk scale according to the PROMETHEE method risk scale.

Determination of Time Performance Criteria

Table 5. Recapitulation of Risk Value

No	Risk Variables	Mean
R1	Culture and customs of the surrounding community	41.67
R2	Lack of working hours	34.17
R3	demonstrations/riots	32.50
R4	unavailability of materials	35.00

Based on the results of the questionnaire recapitulation related to the assessment of the mean value above against time, the highest average value is obtained, namely the variable culture and costums of the surrounding community

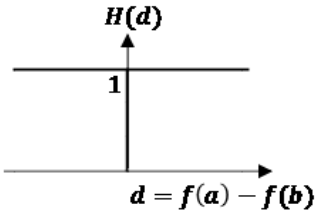
Time Performance Evaluation Table

To use the Promethee method, the first step is creating an Evaluation Table.

Evaluation Table can see at the Table 6. The evaluation table is a table that contains the risk criteria, the preference type used, and also the parameters of the selected criteria type.

The preferences degrees value H(d) can be done by evaluation of the absolute deviation value of the parameters (q,p) and the corresponding criterion type for each criteria according to the maximize/minimize functions. In this analysis, time and cost risks use type I criterion, which means that if the risk affects then the value is 1 and if it does not affect then the value is 0 so that in type I there are no parameters in its us

Fig. 3 Type I Insensitive



$$H(d) = \begin{cases} o\ if\ d = 0, \\ 1, if\ |d| > 0 \end{cases}$$

- Correspond to classical (I, P) situation
- Insensitive to d

H(d) = 0 if d = 0

H(d) = 1 if d≠0

Table 6. Evaluation Table

Criteria	Min/Max	Risk			
		r1	r2	r3	r4
A1	Max	41.67	34.17	32.50	35.00

Description:
A1: Time Criteria,
R1: Culture and customs of the surrounding community
R2: Lack of working hours
R3: Demonstrations/riots
R4: Unavailability of materials
Assuming $wi\frac{1}{2} = 0{,}5$

Determination Time Performance Preference Values

The preferences values used in Promethee are to find out how much preference a criterion has over other criterion. this covers all criterion included in the risk selections. preference values are done in pairs between two types of risks.

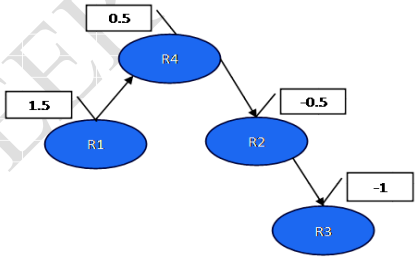
Table 7. Preference (i,j) Value Wi 0.5

Risk	R1	R2	R3	R4	$\emptyset^+$	$\emptyset$	Ranking
R1	0	0.5	0.5	0.5	1.5	1.5	1
R2	0	0	0.5	0	0.5	-0.5	3
R3	0	0	0	0	0	-1.5	4
R4	0	0.5	0.5	0	1	0.5	2
$\emptyset^-$	0	1	1.5	0.5			

Description:
$\emptyset^+$: Positive Outranking Flow
$\emptyset^-$: Negative Outranking Flow

From the table 7 above, it can be seen that local culture and customs are ranked first, followed by material unavailability, lack of working hours, and demonstrations/riots.

Fig. 4 Time Criteria PROMETHEE Analysis Results Diagram



Determination of Cost Performance Criteria

The analysis used is the same as for time performance

Table 8. Recapitulation of Risk Mean Value

No	Risk Variables	Mean
R1	Culture and customs of the surrounding community	40.83
R2	Delay in delivery of materials from suppliers	35.83
R3	unavailability of materials	31.67
R4	increase in material prices	33.33

Then in the results of the recapitulation of the mean assessment of the cost at table 8, culture and customs of the surrounding community remains ranked first

Cost Performance Evaluation Table

The analysis used in the cost performance evaluation table is the same as for time performance.

Table 9. Evaluation Table

Criteria	Min/Max	Risk			
		r1	r2	r3	r4
A2	Max	40.83	35.83	31.67	33.33

A2: Cost Criteria,
R1: Culture and customs of the surrounding community
R2: Delay in delivery of materials from suppliers
R3: unavailability of materials
R4: increase in material prices
Assuming wi $= \frac{1}{2} = 0{,}5$

Determination of Cost Perfomance Preference Values

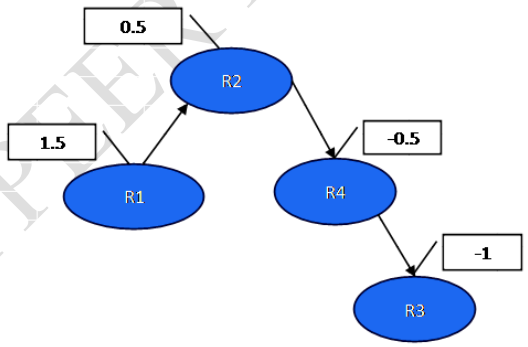
To determine the determination of cost performance preference values, the same method as for time performance is used.

Table 10. Preference (i,j) Value Wi 0.5

Risk	R1	R2	R3	R4	$\emptyset^+$	$\emptyset$	Ranking
R1	0	0.5	0.5	0.5	1.5	1.5	1
R2	0	0	0.5	0.5	1	0.5	2
R3	0	0	0	0	0	-1.5	4
R4	0	0	0.5	0	0.5	-0.5	3
$\emptyset^-$	0	0.5	1.5	1			

Description:
$\emptyset^+$: Positive Outranking Flow
$\emptyset^-$: Negative Outranking Flow
From table 11 above, it can be seen that local culture and customs ranked first, followed by Delay in delivery of materials from suppliers, increase in materials prices, and finally unavailability of materials.

Fig. 5 Time Criteria PROMETHEE Analysis Results Diagram



Discussion

From the results of this study, it is found that the risk to time performance is the variable "culture and customs of the surrounding community" which is the first ranked risk in the analysis using the promethee method caused by ownership of the work site by several different customary areas, then in the second rank is the variable "material unavailability", because materials that have special specifications must be pre-ordered, in the third rank is "lack of working hours", due to not being able to organize and apply work time according to work needs. then in the fourth rank in time performance there.

Results and Discussion:-

In the research on the implementation of the bridge construction project in Papua, the following analysis results were obtained:

1. Characteristics The highest cost and time performance risk in bridge construction in Papua is the cultural

customs of the surrounding community.

2. The most dominant level of risk in bridge construction projects in Papua is "cultural customs of the surrounding community" being a risk factor with the highest level of risk to both time and cost performance.

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