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Research Paper

Risk Analysis on Road Construction: A Case Study of Sumbernanas Road

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ABSTRACT: *In this paper, construction risk that may come up during construction of Sumbernanas road is analyzed. It is intended to find out risk potentials during construction and mitigation action that should be taken. Risk analysis during road construction is crucial because it helps project owner and contractors to anticipate potentials risk and to make sure that the project of road construction will be successfully accomplished. Field survey, literature review, questionnaire and interview are conducted to obtain data. Then, they are analyzed by using risk management framework of analysis. The finding show that there are 12 risk variables and 51 risk indicators. Among them, 11 risk variables fall into high risk category that should be anticipated by formulating mitigation action*
KEYWORDS: *Risk, Construction, mitigation*

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I. INTRODUCTION

In Malang regency, road plays fundamental role to support economic development, education and tourism activities. Therefore, one of the statements of vision and mission of Head of Malang regency is to provide good and sufficient length of road. It is then elaborated into the annual program of Office of Public Works Bina Marga of Malang regency. It is also crucial because Malang regency has wide area surrounded by mountains and lowlands. Good condition and adequate length of road ensures smooth movement of people and goods around and outside area of Malang Regency. As producers of several farming yields, road is needed to send the farming product from Malang area to other areas. It in turns, will facilitate economic development of Malang. Therefore as the manifestation of statement of vision and mission of Head of Malang regency, Public work office of Bina Marga Malang initiated construction of Sumbernanas Road which is located in Gedangan with the length of 875 meters.

However, every construction project has its own risks. They are technical and non-technical risks. The first kind of risks is those related to human, equipment, material and technology used for construction. The latter are risks due to weather condition, economic, social and environmental factors as well as financial and other factors which may influence the construction project. Another risk factor that should be taken into serious consideration is work safety and health. Every construction project must have firm standard operating procedures for work safety and health. The absence of such procedure may put not only the construction worker but also the project completion at risk (Rahmawati, 2020). Furthermore, it is also possible that construction risks affect budget, timeline and quality of project. Shortly, the project will fail cause of of bad risk management (Kerzner, 2013)

Therefore, there is a need for risk management during project construction of Sumbernanas road. It is due to construction project in Malang regency poses risks caused by geographical condition of Malang regency. Effective risk management helps project owner and contractors to plan project effectively. Risk management is also useful to ensure the success of project by formulating mitigation action for relevant risks of projects.

II. LITERATURE REVIEW

A. Management of Project Construction

In Project Body Management of Knowledge (PMBOK), it is stated that project management is process of planning, organizing and making use of companies' resources to create unique products or services (PMI, 2017). There are five process involved in project management. They are project initiation, project planning, project execution, project supervision and control and project closing. It is also stated in PMBOK that there are ten important domains in project management. They are

- Management of project integration
  It concerns with processes and activities to identify, determine, combine and coordinate all processes and activities of projects.
- Management of project scope
  It concerns with all processes and activities required for project completion.
- Management of project schedule
  It concerns with all processes and activities need to manage project punctually
- Management of project budget
  It deals with all processes and activities needed to manage project spending to meet the approved budget
- Management of project quality
  It deals with all processes and activities to take quality principles on planning, managing and supervising project into account in order to fulfill stakeholders 'need.
- Management of project resources
  It concerns with all processes and activities to identify, obtain, and manage resources for project completion.
- Management of project communication,
  It deals with all activities and processes to ensure that all project information are accessible for stakeholders.
- Management of project risk
  It deals with processes and measures to improve positive impact and to reduce negative impact of risk.
- Management of project procurement
  It concerns with all processes and activities required to purchase product, service or others needed for project completion.
- Management of project stakeholders
  It deals with efforts to identify person, groups or organization which are able to influence the project, to analyze their expectation and their impact for the project and to formulate management strategy to involve the stakeholders

B. Risk Management

Risk management is a systematic process to identify, analyze, respond and control risk factors. It aims at preventing or reducing negative effect caused unexpected factors that may jeopardize the project. Risk management also aims at finding out contingency measures for the risks. Flanagan & Norman also stated that risk management is a decision making process called Risk Management System which consists of five stages. They are risk identification, risk classification, risk analysis, attitude to risk and response to risk (Flanagan R & Norman, 1993).

- Risk identification
  It deals with process to finding out potential risks during project implementation. It is a systematic and continuous process. Godfrey identifies several risk sources. They are political risk, environmental risk, economic risk, planning risk project risk, technical risk, financial risk, human risk, material risk, tools risk, criminal risk, safety risk [11]
- Risk classification
  It is a process of classifying risks based on their risk level. It might be classified into three category namely Risk on Material and Equipment, Risk on Manpower, Risk on Project Implementation, Risk on Design and Risk of Nature.
- Risk analysis
  After classifying the risks, then they are analyzed based on their impact and occurrence level.
- Attitude to risk
  It deals with how risks are handled.
- Response to risk

It concerns with how relevant personnel formulate necessary measures to respond to risk. It aims at reducing risk impact. The process is also called risk mitigation

Based on literature review, journals, interview and field observation, risk variables are formulated. They are

- Risk of political factor
- Risk of environmental factor
- Risk of planning factor
- Risk of project factor
- Risk of material
- Risk of equipment
- Risk of manpower
- Risk of financial factors
- Risk of natural factors
- Risk of economic factors
- Risk of criminal factors
- Risk of safety factors

III. RESEARCH METHOD

3.1. Research Design

This study is descriptive one in which quantitative approach is used to obtain accurate and systematic description of data. It is intended to investigate risk variables that may come up during road construction project of Sumbernanas. The risk variables are formulated from literature study, journal and field observation.

3.2. Types of Data

In this study, two types of data are used namely primary and secondary data.

- Primary data
  It is obtained directly from respondents. Questionnaires and interviews are used to obtain this data.
- Secondary data
  This type of data is obtained from journal, books, relevant studies and field survey. The data are used to formulate risk factors concerning with road construction project.

3.3. Respondents of Research

They are 12 respondents of this study. They are those involved in construction project of Sumbernanas to whom the questionnaires are distributed. The respondents are

- Commitment making officials (CMO)
- Technical project implementer officials for Planning and Supervision
- Technical project implementer officials for road construction project.
- Site supervisor from Public works office of Bina Marga.
- Director of company
- Site manager
- Safety officials.
- Director of planning consultant.
- Project planning team.
- Director of Supervisory Consultant
- Field site inspectors

3.4. Research Operational Variables

There are 12 risk variables that are formulated from preliminary studies, journals, and interview and field observation. Each risk variables is then broken down into risk indicators that are put into questionnaire and given to respondents. The risk variables and their indicators are coded and specified in following table

Table 1 Risk Variable

No	**Risk Variables**	**Code**
1	Political Factor	
	a. Policy of regional government	A1
	b. Change on design and work technical aspects	A2
	c. Problems concerning conflict resolution with other parties	A3
	d. Lack of coordination among related parties	A4
	e. Substitution on person in charge in government	A5
2	Environment factor	
	a. Noise due to the use of heavy equipment	A6
	b. Insecure environment of project	A7
	c. Permission from local people	A8
	d. Difficult access to project site	A9
	e. Change on site usage	A10
3	Planning factor	
	a. Design change	A11
	b. Fault design by engineer	A12
	c. Incomplete design data	A13
	d. Vagueness of information on project scope	A14
	e. Selection of road solidification type	A15
4	Project Factor	
	a. Contract and work order signing	A16
	b. Change on work schedule	A17
	c. Change on work scope	A18
	d. Different measurement scale between work design and field condition	A19
	e. Different elevation on excavation to that in work design	A20
	f. Lack of supervision during project implementation	A21
5	Material Factor	
	a. Fault time frame for material order	A22
	b. Delay of material delivery	A23
	c. Lack of material during project	A24
	d. Availability of material used	A25
	e. Material placement during project	A26
6	Equipment Factors	
	a. Inadequate number of equipment	A27
	b. Damage on equipment	A28
	c. Wrong specification of equipment	A29
7.	Manpower factors	
	a. Incompetent manpower	A30
	b. Carelessness of manpower	A31
	c. Inadequate number of manpower	A32
	d. Culture of manpower	A33
	e. Fatigue on the part of manpower due to extra work	A34
8	Financial Factors	
	a. Noncurrent cash flow	A35
	b. Payment Delay to supplier	A36
	c. High operational cost and overhead	A37
	d. Payment delay from owner	A38
9	Nature Factors	
	a. Rain fall	A39
	b. Landslide	A40
10	Economic Factors	
	a. Tax increase	A41
	b. Fuel price increase	A42
	c. Price escalation during project implementation	A43
11	Criminal Factors	
	a. Theft	A44
	b. Lack of project security	A45
	c. Damage	A46
12	Safety Factors	
	a. Lack of safety equipment use	A47
	b. Lack of Self-safety equipment	A48
	c. Manpower awareness to apply safety procedures	A49
	d. Dangerous substance	A50
	e. Structure collapse	A51

3.5. Research Instrument

In this study, questionnaire is used to gather data on occurrence and impact of risk. Risk occurrence is measured by using 1 – 5 scale. The questionnaire consists of three sections namely respondents' profile, Project information and 51 items of questionnaires.

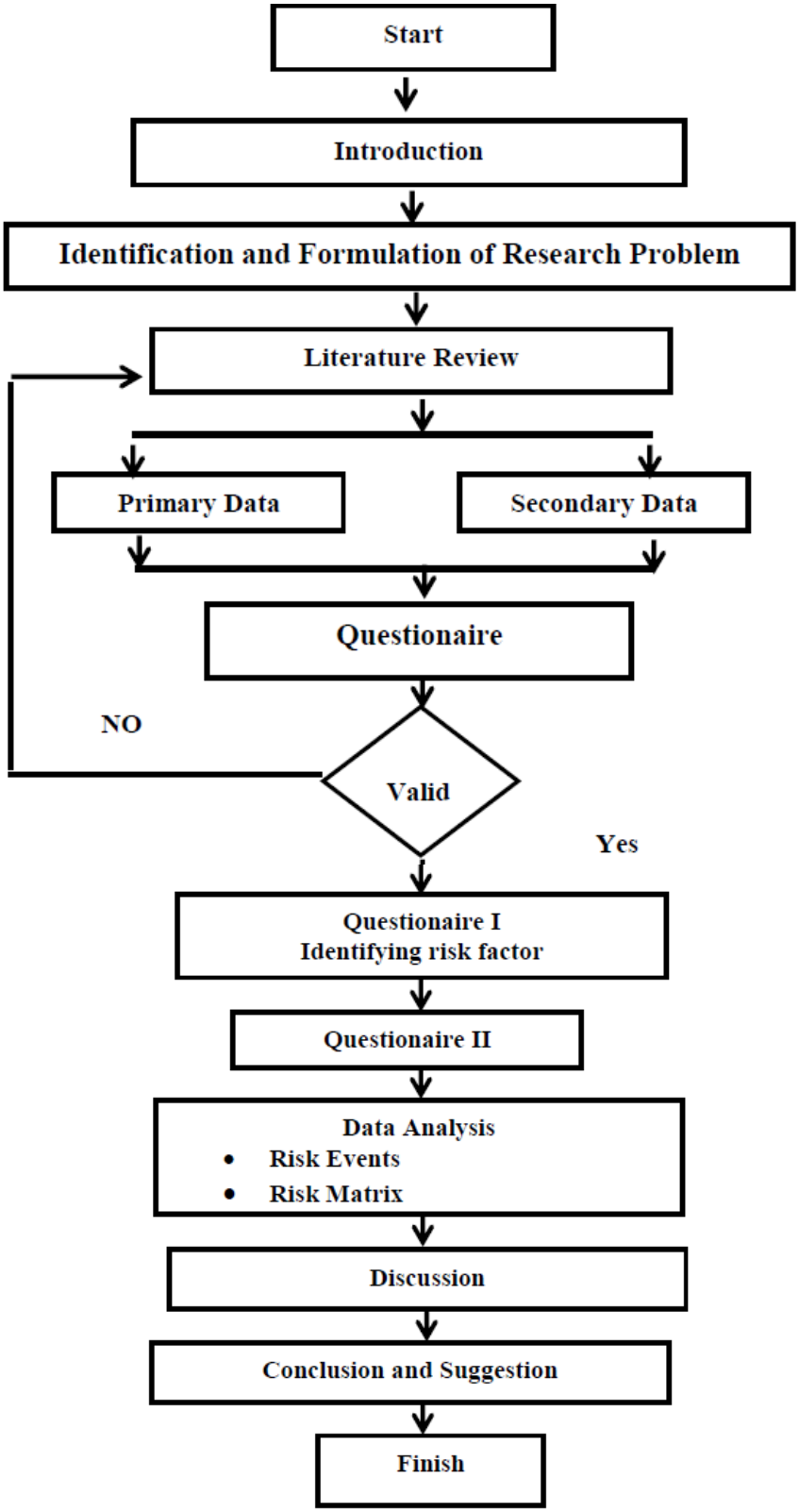
3.6. Data Analysis

Data obtained from questionnaire are analyzed by using the following procedures.

a. To analyze data obtained from questionnaire I which are distributed during field survey I
   Data on relevant risk factors are identified based on the result of questionnaire 1. Then in order to find out probability level of risk occurrence and risk impact, questionnaires are distributed in survey II
b. To analyze data from questionnaire 2
   On this stage, *Severity index* method, probability matrix and risk impact analysis are applied aiming at obtaining data on probability and impact of risk.
c. To analyze risk factors
   Data obtained from questionnaire II, are then analyzed by using scoring scale ranging from "very small" (risk potentials ≤20%), "small" (risk potentials of ≤40%) and "very big" (risk potentials of 80-100%).
d. To rank risk factors
   In this stage, risk factors are ranked by using the following formula
   FR = (L+I) – (LxI)
   Where
   FR = risk factors, scale of 0-1
   L = probability of risk events (0 – 100%)
   I = scale of risk impact
e. To compose risk matrix
   Risk matrix is formulated by inputting risk values on a matrix. It is then used to determine which risk factors with the biggest probability of occurrence and impact.

3.7. Flowchart of Research

Stages of this research are elaborated in the following flowchart.



IV. RESULT AND DISCUSSION

4.1. Questionnaire Validation

Since this research uses questionnaire to obtain data, then it should be validated. Expert validation is employed for that. The criteria of validity is that the risk factors are considered valid or relevant if the answers for each factors are at least 4 variables and if the responses are >50%. Below is the result of expert validation for instruments.

Table 2 Validation Result

No	Risk Indicators	Relevant	Irrelevant	Status
1	Regional government Policy	7	0	Valid
2	Change on design and work technical aspects	5	2	Valid
3	Problems concerning conflict resolution with other parties	5	2	Valid
4	Lack of coordination among related parties	4	3	Valid
5	Substitution on person in charge in government	6	1	Valid
6	Noise due to the use of heavy equipment	5	2	Valid
7	Insecure environment of project	5	2	Valid
8	Permission from local people	5	2	Valid
9	Difficult access to project site	5	2	Valid
10	Change on site usage	5	2	Valid
11	Design change	5	2	Valid
12	Fault design by engineer	5	2	Valid
13	Incomplete design data	4	3	Valid
14	Vagueness of information on project scope	5	2	Valid
15	Selection of road solidification type	5	2	Valid
16	Contract and work order signing	4	3	Valid
17	Change on work schedule	5	2	Valid
18	Change on work scope	5	2	Valid
19	Different measurement scale between work design and field condition	6	1	Valid
20	Different elevation on excavation to that in work design	6	1	Valid
21	Lack of supervision during project implementation	5	2	Valid
22	Fault time frame for material order	5	2	Valid
23	Delay of material delivery	6	1	Valid
24	Lack of material during project	5	2	Valid
25	Availability of material used	5	2	Valid
26	Material placement during project	6	1	Valid
27	Inadequate number of equipment	6	1	Valid
28	Damage on equipment	6	1	Valid
29	Wrong specification of equipment	6	1	Valid
30	Incompetent manpower	5	2	Valid
31	Carelessness of manpower	6	1	Valid
32	Inadequate number of manpower	6	1	Valid
33	Culture of manpower	6	1	Valid
34	Fatique on the part of manpower due to extra work	6	1	Valid
35	Noncurrent cash flow	5	2	Valid
36	Payment Delay to supplier	6	1	Valid
37	High operational cost and overhead	5	2	Valid
38	Payment delay from owner	6	1	Valid
39	Rain fall	5	2	Valid
40	Landslide	5	2	Valid
41	Tax increase	6	1	Valid
42	Fuel price increase	5	2	Valid
43	Price escalation during project implementation	5	2	Valid
44	Theft	5	2	Valid
45	Lack of project security	6	1	Valid

46	Damage	7	0	Valid
47	Lack of safety equipment use	5	2	Valid
48	Lack of Self-safety equipment	6	1	Valid
49	Manpower awareness to apply safety procedures	5	2	Valid
50	Dangerous substance	5	2	Valid
51	Structure collapse	5	2	Valid

4.2. Risk Impact and Occurrence

Questionnaire I distributed to respondents result in data on Risk Impact and Occurrence scored by using scale of 1 – 5. The result of questionnaire I is presented below

Table 3 Data on Risk Impact and Occurrence

No	Risk Indicators	Occurrence		Impact	
		Mode	Mean	Mode	Mean
1	Regional government Policy	3	3.17	3&4	3.17
2	Change on design and work technical aspects	1	1.50	2	2.75
3	Problems concerning conflict resolution with other parties	2	2.67	2	2.83
4	Lack of coordination among related parties	3&4	3.50	3&4	3.50
5	Substitution on person in charge in government	3	3.00	3	2.75
6	Noise due to the use of heavy equipment	4	2.33	2	2.08
7	Insecure environment of project	3&4	3.25	3&4	3.25
8	Permission from local people	4	3.58	3&4	3.17
9	Difficult access to project site	3	3.00	3	3.67
10	Change on site usage	3	2.92	3	3.00
11	Design change	4	3.17	3&4	3.25
12	Fault design by engineer	2	2.42	2&3	2.50
13	Incomplete design data	2	2.58	2	2.33
14	Vagueness of information on project scope	3&4	3.25	3&4	3.25
15	Selection of road solidification type	4	3.58	3	3.17
16	Contract and work order signing	3&4	3.25	3&4	3.25
17	Change on work schedule	3	3.00	3	3.00
18	Change on work scope	4	3.33	4	3.33
19	Different measurement scale between work design and field condition	3	3.00	3	3.00
20	Different elevation on excavation to that in work design	2	2.33	2	2.33
21	Lack of supervision during project implementation	2&3	2.50	2&3	2.50
22	Fault time frame for material order	2&3	2.83	2&3	2.83
23	Delay of material delivery	3&4	3.25	4	3.67
24	Lack of material during project	4	3.75	3	3.17
25	Availability of material used	4	3.42	4	3.67
26	Material placement during project	4	3.33	2	2.92
27	Inadequate number of equipment	2	2.75	1	2.17
28	Damage on equipment	2	2.42	2	2.67
29	Wrong specification of equipment	2	2.42	2	2.50
30	Incompetent manpower	3	3.00	4	3.33
31	Carelessness of manpower	3	3.00	3	3.08
32	Inadequate number of manpower	4	3.42	3	2.92
33	Culture of manpower	3&4	3.25	2	2.83
34	Fatigue on the part of manpower due to extra work	4	2.75	3	3.17
35	Noncurrent cash flow	3	3.08	2	2.67
36	Payment Delay to supplier	4	3.58	1	1.83
37	High operational cost and overhead	3&4	3.17	2	2.00
38	Payment delay from owner	3	3.00	3	3.17
39	Rain fall	1	2.25	3	3.00
40	Landslide	2	2.67	2	2.08
41	Tax increase	2&3	2.50	2	2.67
42	Fuel price increase	3	2.92	2	2.58

43	Price escalation during project implementation	3	3.08	3	3.00
44	Theft	3&4	3.25	1	2.42
45	Lack of project security	3	3.08	2	2.75
46	Damage	1	2.17	1	2.17
47	Lack of safety equipment use	2	2.58	4	3.00
48	Lack of Self-safety equipment	2	2.58	4	3.00
49	Manpower awareness to apply safety procedures	3&4	3.25	3	3.17
50	Dangerous substance	2	2.75	1	2.50
51	Structure collapse	1	1.75	1	1.92

The next step is to calculate matrix by matching result of scoring for rick occurrence and risk impact. The result is presented below

Table 5 Matched Matrix on Possibility and Occurrence of Risk

No	Very Low	Low	Moderate	High	Very High
Very small	1	2	3	4	5
Small	0.8	1	2	3	4
Moderate	0.6	0.8	1	2	3
Big	0.4	0.6	0.8	1	2
Very Big	0.2	0.4	0.6	0.8	1
Total	**3**	**4.8**	**7.4**	**10.8**	**15**

4.3. Severity Level of Risk

Severity level of risk is scored by using scale of risk of occurrence based on AS/NZS4360:1999 on Risk Management as stated below

- SI = < 20 = 1 = very rarely
- SI = 20 - < 40 = 2 = rarely
- SI = 40 - < 60 = 3 = occasionally
- SI = 60 - < 80 = 4 = often
- SI = 80 - < 100 = 5 = very often

The result is as follows

Table 6 Severity Index for Risk Possibility

No	**Risk Indicators**	**SI**	**Scale**
1	Regional government Policy	63.33	4
2	Change on design and work technical aspects	30.00	2
3	Problems concerning conflict resolution with other parties	53.33	3
4	Lack of coordination among related parties	70.00	4
5	Substitution on person in charge in government	60.00	3
6	Noise due to the use of heavy equipment	46.67	3
7	Insecure environment of project	65.00	4
8	Permission from local people	71.67	4
9	Difficult access to project site	60.00	3
10	Change on site usage	58.33	3
11	Design change	63.33	4
12	Fault design by engineer	48.33	3
13	Incomplete design data	51.67	3
14	Vagueness of information on project scope	65.00	4
15	Selection of road solidification type	71.67	4
16	Contract and work order signing	65.00	4
17	Change on work schedule	60.00	3
18	Change on work scope	66.67	4
19	Different measurement scale between work design and field condition	60.00	3
20	Different elevation on excavation to that in work design	46.67	3
21	Lack of supervision during project implementation	50.00	3
22	Fault time frame for material order	56.67	3
23	Delay of material delivery	85.00	5
24	Lack of material during project	65.00	4
25	Availability of material used	75.00	4
26	Material placement during project	68.33	4
27	Inadequate number of equipment	66.67	4
28	Damage on equipment	55.00	3
29	Wrong specification of equipment	48.33	3

30	Incompetent manpower	48.33	3
31	Carelessness of manpower	60.00	3
32	Inadequate number of manpower	60.00	3
33	Culture of manpower	68.33	3
34	Fatigue on the part of manpower due to extra work	65.00	4
35	Noncurrent cash flow	55.00	3
36	Payment Delay to supplier	61.67	4
37	High operational cost and overhead	71.67	4
38	Payment delay from owner	63.33	4
39	Rain fall	60.00	3
40	Landslide	45.00	3
41	Tax increase	53.33	3
42	Fuel price increase	50.00	3
43	Price escalation during project implementation	58.33	3
44	Theft	61.67	4
45	Lack of project security	61.67	4
46	Damage	43.33	3
47	Lack of safety equipment use	51.67	3
48	Lack of Self-safety equipment	51.67	3
49	Manpower awareness to apply safety procedures	65.00	4
50	Dangerous substance	55.00	3
51	Structure collapse	35.00	3

4.4. Risk Matrix

Based on risk severity, then matrix of risk is formulated. It aims at determining the risk ranking which in turn to be basis of risk mitigation. The matrix is as follow

Table 7 Risk Matrix

IMPACT					
Possibility for occurence	(1) Very small	(2) Small	(3) Moderate	(4) Big	(5) Very Big
5 (Very often)	M	M	H	23	E
4 (Often)	L	34	7, 8, 26, 27, A37, 38, 44, 45,	1,4,7, 8, 11, 14, 15, 16,18, 24, 25, 36,49	H
3 (Occasionally)	L	35, 51	3, 5, 6, 9, 10, 12, 13, 17, 19, 20, 21, 22, 28, 29, 32, 33, , 39, 40, 41, 42, 43, 46, 47, 48, 50, 51	30, 31	H
2 (rarely)	L	L	A2,	M	H
1 (very rarely)	L	L	L	L	M

High Risk

Moderate Risk

Low Risk

4.5. Risk Mitigation

After identifying the risk variable based on the matrix above, mitigation actions are formulated based on the input from relevant expert. The mitigation actions are as follows

Table 8 Risk and Mitigation Actions

No	Risk Variables	Mitigation Action
A23	Delay of material delivery	To make schedule of delivery approved by Commitment Making Officials
A1	Regional government policy	To compose program to construct and maintain road proposed by Public Work Office of Bina Marga
A4	Lack of coordination	To make coordination schedule between Public Work office of Bina Marga and relevant parties
A7	Environmental safety	To conduct cooperation between Public work office of Bina Marga and Police department
A8	Permission from local people	To conduct socialization and obtain participation

		from community
A11	Design Change	To formulate procedure in which Public Work Office of Bina Marga is required to review and approve design change.
A14	Vagueness of Information on Project scope	To conduct coordination between planning consultant and Public Work office of Bina Marga followed by location survey
A15	Selection of road solidification type	To make alternative design based on project budget by Planning consultant.

V. CONCLUSION

Due to possibility of risk during project construction, risk analysis is crucial for Sumbernanas road construction project. Based on the analysis above, the findings shows that there 51 risk indicators that can be identified. There are16 variables of them that falls into high risk category. In addition, risk having the biggest impact is Delay of Material delivery. It is possible that the project will be the subject of failure if we fail to tackle the risk. Therefore, it is crucial to formulate the mitigation action. For Delay of Material risk, the mitigation action is to make schedule which is consulted to relevant parties and approved by Commitment Making Officials.

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