Risk analysis and strategic planning on bridge construction works at the toll road procurement projects in Central Java Province

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Abstract. Risk is a condition caused by uncertainty. Risks will occur on any construction project, including bridge construction projects. Efforts that can be taken to minimize the impact of these risks are to engage in risk management activities. This research was conducted on bridge construction work on toll road procurement project in Pejagan-Pemalang, Pemalang-Batang and Salatiga-Kertasura. The purpose of this research is to analyze the risk of bridge development project in toll road project using Risk Breakdown Structure (RBS) method and then the result as database in discussing risk response strategy. The bridge construction project has 36 risks that are divided into six groups: materials and equipment, design, human resources, finance, management, nature and environmental conditions. Bad weather risks are the higest risk and seasonal risk causing temporary work stoppages. This risk-response strategy is avoidance. Short-term avoidance response strategy is to add shift workers, install tents and add additives in the acceleration of the process of maturation of concrete. The long-term avoidance response strategy is to evaluate and rearrange the work schedule by considering the weather forecast report.

1 Introduction

Some Toll Road Projects in Central Java Province which are parts of Mega Trans Java Project (Cikampek West Java - Gempol East Java along 652 Km) are still under construction. Among them are the Pejagan-Pemalang, Pemalang-Batang and Salatiga-Kertasura Road Projects. In those projects, there are bridge projects whose existence is quite essential; therefore it needs maximum handling efforts, including risk mitigation. Risk is a consequence of uncertain conditions in a project. There is a correlation between risk and the quality of construction project implementation [1].

Risks in bridge construction projects may include financial risk, external risk, design risk, management risk, construction risk, contractual risk, and health and safety risks [2]. Mitigation of risk can be carried out by conducting risk management plans. A risk management plan is considered as an attempt of analyzing risks that can enrich the decision-making process and provide additional arguments to help choosing the optimal

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variant using multiple approaches [3]. Nevertheless, the risk management policies should be implemented and evaluated regularly to minimize the probability of failure [4].

This study aims to analyze the risks in the bridge construction project at the toll road project. In the analysis conducted will be known the risks that influence, value, category, and mitigation of each risk.

2 Literatur Review

2.1 Risk Management

The risks in the construction project are irreversible, but their impacts can be minimized [5]. An effort which can be done to minimize the impact is to carry out risk management activities [2]. International Standard (2009) [6] describes 5 (five) stages of risk management process: (1) Establish the context; This shows the relationship between the problem and the organization environment, the risk management process and the standard risk criteria, (2) Risk Identification; The identification process includes: what risks, when, where, how and why risks can occur, (3) Risk Analysis; Determine how much impact and possible risks will occur. Then the level of each risk is determined, (4) Risk Evaluation; Risk evaluation is carried out by comparing the estimated risk level against predetermined criteria and (5) Risk Treatment; Risk treatment is the stage of development and implementation of strategies and action plans for the selection of the best response.

2.2 Risk Breakdown Structure Method (RBS)

RBS is an aid for identifying, assessing, comparing, and reporting risk. A long list of risks can be hard to structure and prioritize, therefore the RBS can be a more effective tool to breaking down the risks and helping the project manager focus attention on certain risks. According to Hillson [7], RBS results risk response planning that will be useful as future project guideline.

RBS is a hierarchical structure of the source of risk, the method of grouping project risk based on the source that can organize and define the overall risk faced by a project. In general, RBS will be divided into 4 (four) levels, namely: References to printed journal articles should typically contain: Level 0 states a risky program, Level 1 is a global grouping such as a bridge construction project risk, Level 2 is a category of level 1 in the form of grouping of several risks such as planning risk group, risk contract group, operational risk group and so on, and Level 3 is a more specific risk description according to level 2.

3 Reseach Methods

The object of this research is the bridge project in the Pejagan-Pemalang Toll Road Project (17 bridges), Pemalang-Batang (27 bridges), and Salatiga-Kertasura (12 bridges).
Data collection method used in this research is observation and communication. Observation method used to get secondary data that is by searching data needed in book, journal, and other publication related to research theme. While communication method used to get primary data that is through interview and filling questioner.

Data collection begins with collecting secondary data to identify the initial risks which are then used as a reference for obtaining primary data through interviews and filling in questionnaires. Secondary data were taken using the observation method to obtain / identify the initial risks which were then used as reference in obtaining the primary data. Primary data is taken using the method of communication through interviews and filling questionnaires distributed in 2 (two) stages. Questionnaire I is a risk validation effort, questionnaire II is an effort to assess the frequency and impact level.

This research uses purposive sampling technique that is sample determination technique with certain considerations, so there is no limitation related to the number of samples. Respondents in this study are stakeholders that include contractors and supervisory consultants. Questionnaire I, respondents are experts / experts who have at least 5 years experience working on construction projects. While Questionnaire II, respondents are technical staff from contractors and supervisory consultants. Data analysis performed include nonparametric test, validity test, reliability test and risk analysis with Risk Breakdown Structure (RBS) method.

The purpose of this study was to explore the risk factors on the bridge project. This research is exploratory research. In this study, the factors affecting the bridge construction project are explored in depth. After obtaining the research factors with exploratory research, then these factors become the basis in preparing the questionnaire which is then analyzed to know the impact and its management. The method of analysis used is Risk Breakdown Structure (RBS). Hillson [7], states that RBS is a hierarchical structure of risk sources that can define the overall risk faced by a project. After the risk hierarchy is formulated then proceed with determining the value of the frequency level as a reference in categorizing and ranking each risk.

The variables in this study are risk factors derived from several references that are then validated using communication methods that is through questionnaires and interviews. The variables in this study can be seen in Table 1.

Table 1. The Exploration of Risk Factor

No.	Risk Factors	Reference
	Materials and Equipment	
1	Material Shortage	Asmarantaka, 2014 [8]
2	Material Error on form, function and specification	Asmarantaka, 2014 [8]
3	Delay of Material Supply	Asmarantaka, 2014 [8]
4	Material Damage in Storage	Asmarantaka, 2014 [8]
5	Material Scarcity	Asmarantaka, 2014 [8]
6	Inaccurate timing of material order	Asmarantaka, 2014 [8]
7	Delay of Equipment	Research Proposal
8	Equipment Damage	Winaktu et al., 2014 [9]
9	Equipment Shortage	Asmarantaka, 2014 [8]
10	Equipment Productivity	Asmarantaka, 2014 [8]
	Design	
11	Design Changes	Vidivelli et al., 2017 [10]
12	Design Variation	Zou et al., 2006 [11]
13	Error in Design by Planner	Asmarantaka, 2014 [8]
14	Error in drawing/specification	Taufik, 2010 [1]
15	Unclear information on the scope of work at the time of job description	Taufik, 2010 [1]
	Human Resource	
16	Less professional	Zou et al., 2006 [11]
17	Less labor	Zou et al., 2006 [11]
18	Low labor ability	Asmarantaka, 2014 [8]
19	Low labor productivity	Choudhry and Aslam,

No.	Risk Factors	Reference
		2011 [2]
	Finance	
20	Inflation	Choudhry and Aslam, 2011 [2]
21	Financial Failure of the Contractor	Choudhry and Aslam, 2011 [2]
22	Poor Estimation of Unexpected Cost	Research Proposal
23	Incomplete Cost Estimation	Zou et al., 2006 [11]
24	Unrealistic Cost estimation	Vidivelli et al., 2017 [10]
25	Late Payment	Vidivelli et al., 2017 [10]
	Management	
26	Error in Understanding Contract Document	Asmarantaka, 2014 [8]
27	Document is incomplete	Zou et al., 2006 [11]
28	Less coordination	Vidivelli et al., 2017 [10]
29	Dispute	Zou et al., 2006 [11]
30	Inadequate project information (soil test and survey report)	Zou et al., 2006 [11]
31	Error in choosing implementation method	Asmarantaka, 2014 [8]
32	Strict project schedule	Zou et al., 2006 [11]
33	Poor program scheduling	Zou et al., 2006 [11]
34	Delay during construction process	Vidivelli et al., 2017 [10]
35	Many work errors require rework	Research Proposal
36	Job implementation does not follow SOP	Asmarantaka, 2014 [8]
37	Bad K3 management	Asmarantaka, 2014 [8]
38	Poor surveillance and site management	Choudhry and Aslam, 2011 [2]
39	Subcontractor failure	Choudhry and Aslam, 2011 [2]
	Nature and Environment Conditions	
40	Earthquake	Winaktu et al., 2014 [9]
41	Landslide	Winaktu et al., 2014 [9]
42	Bad weather	Asmarantaka, 2014 [8]
43	Late permissions	Asmarantaka, 2014 [8]
44	A less secure project development environment	Asmarantaka, 2014 [8]
45	Disagreement interests with citizens	Research Proposal
46	Unstable government policy	Choudhry and Aslam, 2011 [2]
47	Excessive government approval procedures	Zou et al., 2006 [11]

Risk Probability and Impact Assessment is investigating the possibility of occurrence of some specific risks and the potential effects (negative impacts as well as positive impacts) of a project that may affect the project's ultimate objectives such as time, quality, price, scope of work. A commonly used analytical method is Probability and Impact Matrix, where risk can be arranged on a priority scale for the next step of quantitative analysis and risk mitigation.

Evaluation of the importance of each risk, as well as the priority of attention to risks can typically use Table 2. In this table the organization can determine anywhere from a combination of probabilities of risks and the effects of those riks in the classification of high risk, medium risk and low risk. The probability level values consist of values of 0.1 to 0.9 and an impact level value comprising values of 0.05 to 0.8. The probability and impact of the advantages and disadvantages can be analyzed in one matrix, by defining the good from each of the risks from different levels [12].

Table 2. Probability and Impact Matrix

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05/ Very Low	0.10/ Low	0.20/ Moderate	0.40/ High	0.80/ Very High	0.80/ Very High	0.40/ High	0.20/ Moderate	0.10/ Low	0.05/ Very Low

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Quantitative Risk Analysis is a risk analysis based on the risk priority resulting from qualitative analysis. In this method, the risk is analyzed to find out how much effect will be generated by giving a number that indicates the level of risk. The quantitative analysis is to assess the importance of risk to know which risks are most influential to the bridge construction project. The equation for calculating the value of risk level can be seen in equation 1.

$$\textit{Level of risk interest} = \textit{Probability x Impact} \tag{1}$$

This quantitative analysis should be performed again after the Risk Response Planning phase, as part of the Risk Monitoring and Control.

Nonparametric test was conducted to know the level of difference of understanding based on respondent data. The test was performed with the help of SPSS program in the form of testing two samples using Mann Whitney U Test. Validity test is a test used to indicate how accurately the instrument is used. While the reliability test is a test to determine the extent to which the consistency of the instrument used. The validity test is used to find out if there are any questions in the invalid questionnaire that should be discarded. While the reliability test is used to determine whether the instruments in the study can produce consistent data. The testing technique for validity test using SPSS software is by looking at the value of corrected item-total correlation. Testing technique for reliability test also use SPSS software by looking at coefficient value of alpha cronbach.

Once the ranking and risk categories are identified, then an analysis of the causes, impacts and respon of each of the risks can be done. Analysis of causes, impacts and risk management was obtained by conducting interviews with three experts. Risk response planning is a process of developing options and determining the most effective actions so that it is expected to increase the opportunity and reduce the risk seen from the negative side of the challenge. The type of response to risk is divided into four, there are : (1) avoid; the project team acts to eliminate risks or protect the project from its impact, (2) transfer; the project team transfers the impact of risk to a third party, (3) mitigate; the project team acts to reduce the likelihood of occurrence or impact of a risk, (4) accept; the project team decides to recognize the risks and does not take any action unless such risk occurs.

4 Result and Discussion

The analysis begins with identifying risk, followed by validity and reliability test. Data which is valid and reliable is continued to next analysis stage. Risks which affect the bridge construction project can be seen in Table 3.

Table 3. Risk Identification in Risk Breakdown Structure

Level 0		Level 1	Level 2		Level 3	
Risky Program	A	Risks of Conducting Bridge Construction Project	1	Materials and Equipment	X1	Material Shortage
					X2	Material Error on form, function and specification
					X3	Delay of Material Supply
					X4	Material Damage in Storage
					X5	Material Scarcity
					X6	Inaccurate timing of material order
					X7	Delay of Equipment
					X8	Equipment Damage
					X9	Equipment Shortage
			2	Design	X10	Error in Design by Planner
					X11	Design Changes
			3	Human Resource	X12	Less professional
					X13	Less labor
					X14	Low labor ability
			4	Finance	X15	Inflation
					X16	Financial Failure of the Contractor
					X17	Poor Estimation of Unexpected Cost
					X18	Incomplete Cost Estimation
					X19	Late Payment
			5	Management	X20	Error in Understanding Contract Document
					X21	Document is incomplete
					X22	Less coordination
					X23	Dispute
					X24	Inadequate project information (soil test and survey report)
					X25	Error in choosing implementation method

Level 0		**Level 1**	**Level 2**		**Level 3**	
					X26	Less precise in applying the method of implementation
					X27	Poor program scheduling
					X28	Many work errors require rework
					X29	Job implementation does not follow SOP
					X30	Bad K3 management
					X31	Subcontractor failure
			6	Nature and Environment Conditions	X32	Landslide
					X33	Bad weather
					X34	Late permissions
					X35	A less secure project development environment
					X36	Disagreement interests with citizens
					X37	Unstable government policy

Validity test is performed on the frequency and impact of risk with corrected item-total correlation technique by comparing the r value of SPSS and r table (37 variables is 0.324). The variable declared invalid as the value of r arithmetic < r table is a design change with the value of r count frequency of 0.312. Reliability test performed on frequency and impact of risk with alpha cronbach technique. Based on the analysis that has been done, the instrument is stated reliable if the value of alpha cronbach> 0.6.

Recapitulation of respondent's answer to frequency and impact is analyzed and reciprocated to obtain value of risk level. Based on these values determined the category and handling strategies required.

Table 4. The Value of Frequency, Impact, Level of Interest, Category, and Strategy of Handling

Variable	Risks	Frequency (a)	Impact (b)	Level of Risk Interest (axb)	Risk Category	Risk Handling Strategy
	Material and Equipment					
X1	Material Shortage	0,346	0,231	0,080	Medium	Mitigation
X2	Material Error on form, function and specification	0,263	0,222	0,058	Low	Monitoring
X3	Delay of Material Supply	0,392	0,208	0,082	Medium	Mitigation
X4	Material Damage in Storage	0,346	0,216	0,075	Medium	Mitigation
X5	Material Scarcity	0,292	0,206	0,060	Medium	Mitigation
X6	Inaccurate timing of material order	0,354	0,194	0,069	Medium	Mitigation
X7	Delay of Equipment	0,413	0,255	0,105	Medium	Mitigation
X8	Equipment Damage	0,421	0,228	0,096	Medium	Mitigation
X9	Equipment Shortage	0,433	0,229	0,099	Medium	Mitigation

Variable	Risks	Frequency (a)	Impact (b)	Level of Risk Interest (axb)	Risk Category	Risk Handling Strategy
	Design					
X10	Error in Design by Planner	0,371	0,334	0,124	Medium	Mitigation
X11	Design Changes					
	Human Resource					
X12	Less professional	0,342	0,206	0,070	Medium	Mitigation
X13	Less labor	0,371	0,199	0,074	Medium	Mitigation
X14	Low labor ability	0,342	0,195	0,067	Medium	Mitigation
	Finance					
X15	Inflation	0,225	0,186	0,042	Low	Monitoring
X16	Financial Failure of the Contractor	0,238	0,271	0,064	Medium	Mitigation
X17	Poor Estimation of Unexpected Cost	0,379	0,175	0,066	Medium	Mitigation
X18	Incomplete Cost Estimation	0,358	0,175	0,063	Medium	Mitigation
X19	Late Payment	0,433	0,225	0,098	Medium	Mitigation
	Management					
X20	Error in Understanding Contract Document	0,233	0,193	0,045	Low	Monitoring
X21	Document is incomplete	0,350	0,184	0,065	Medium	Mitigation
X22	Less coordination	0,400	0,229	0,092	Medium	Mitigation
X23	Dispute	0,350	0,185	0,065	Medium	Mitigation
X24	Inadequate project information (soil test and survey report)	0,325	0,249	0,081	Medium	Mitigation
X25	Error in choosing implementation method	0,375	0,252	0,095	Medium	Mitigation
X26	Less precise in applying the method of implementation	0,358	0,274	0,098	Medium	Mitigation
X27	Poor program scheduling	0,400	0,206	0,083	Medium	Mitigation
X28	Many work errors require rework	0,346	0,255	0,088	Medium	Mitigation
X29	Job implementation does not follow SOP	0,354	0,297	0,105	Medium	Mitigation
X30	Bad K3 management	0,296	0,300	0,089	Medium	Mitigation
X31	Subcontractor failure	0,363	0,272	0,099	Medium	Mitigation
	Nature and Environment Condition					
X32	Landslide	0,363	0,327	0,119	Medium	Mitigation
X33	Bad weather	0,617	0,354	0,218	High	Avoiding
X34	Late permissions	0,421	0,220	0,092	Medium	Mitigation

Variable	Risks	Frequency (a)	Impact (b)	Level of Risk Interest (axb)	Risk Category	Risk Handling Strategy
X35	A less secure project development environment	0,358	0,238	0,085	Medium	Mitigation
X36	Disagreement interests with citizens	0,479	0,248	0,119	Medium	Mitigation
X37	Unstable government policy	0,304	0,218	0,066	Medium	Mitigation

Based on the analysis that has been done and presented in table 4, there are 1 (one) risk in high category that is bad weather risk with avoidance strategy, 32 risks in medium category with mitigation handling strategy and 3 (three) low category risk which are material error in form, function and specification, the risk of inflation and the risk of error in the understanding of contract documents with monitoring strategies.

Bad weather is a risk with the highest level of risk interest in the high category, followed by the risk of error in design by the planner which belongs to the medium category. Bad weather is a risk caused by natural factors, so it is often unavoidable. But the fact is, not all jobs are affected by this bad weather. In other words on certain jobs, there are many solutions to overcome these risks. The risks to the project can be eliminated and can even be protected against the impact of the bad weather. So in certain circumstances, this risk is categorized as a risk that can be avoided.

Bad weather risk causes the work to be stopped temporarily. Another impact is also the difficult transportation to enter the project site because the road becomes muddy and slippery. Handling efforts as short-term avoidance response strategies are addition of shift workers to pay back wasted work time. Regarding jobs which are not too dangerous and not at altitudes such as processing iron activity, it will be overcome by the installation of tents during the absence of strong winds. The addition of additives substance to accelerate the process of concrete maturation, supported by the use of non-conventional formwork which can be assembled and unloaded faster to pursue delay in progress of work. While the long-term avoidance response strategy are evaluation and rearrangement the work schedule considering the weather forecast report issued by Badan Meteorologi, Klimatologi, Geofisika (BMKG), so jobs affected by these risks such as casting work, girder beam installation etc. can be scheduled on a good weather. Despite being the highest risk, in fact this risk is a seasonal risk, because it only happens when the rainy season comes.

Another high-level risk is a design error by planners that impact on construction failures. A short-term mitigation response strategy is to find an independent expert design to conduct an evaluation. The project team evaluates and then discusses with the design engineering consultant to revise the design. A long-term mitigation response strategy is to conduct periodic coordination and review with design engineering consultant.

5 Conclusions and Suggestion

The results of the analysis can be drawn the following conclusions: There are 36 risks that affect the bridge construction procurement project. Obtained 1 (one) high category risk that is bad weather risk, 32 moderate category risk and 3 (three) low category risk that is material mistake on form, function and specification, inflation and error occurred in the understanding of contract documents. The risk of bad weather is the greatest risk and the seasonal risk, the handling effort are 2 (two) avoidance response strategies. Short-term response strategies are addition of shift workers to pay back wasted work time to replace the wasted work time, installaion of tents for work that is not at altitude, addition of additives substance to accelerate the process of concrete maturation supported by the use of non-conventional formwork. Long-term response strategy are evaluation and rearrangement the whole of project schedule by considering the weather forecast report issued by BMKG.

This research is conducted on a bridge project along a defined toll road project and does not classify on certain types of bridges. Therefore, it is advisable to conduct research related to risk analysis with more specific bridge classification.

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