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Risk assessment of underpass infrastructure project based on ISO 31000 and ISO 21500 using fishbone diagram and RFMEA (project risk failure mode and effects analysis) method**Bambang Purwanggono¹ and Anastasia Margarette²**5
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Abstract. Completion time of highway construction is very meaningful for smooth transportation, moreover expected number of ownership motor vehicle will increase each year. Therefore, this study was conducted with to analyze the constraints that contained in an infrastructure development project. This research was conducted on Jatingaleh Underpass Project, Semarang. This research was carried out while the project is running, on the implementation, this project is experiencing delays. This research is done to find out what are the constraints that occur in execution of a road infrastructure project, in particular that causes delays. The method that used to find the root cause is fishbone diagram to obtain a possible means of mitigation. Coupled with the RFMEA method used to determine the critical risks that must be addressed immediately on road infrastructure project. The result of data tabulation in this study indicates that the most possible mitigation tool to make a Standard Operating Procedure (SOP) recommendations to disrupt utilities that interfere project implementation. Process of risk assessment has been carried out systematically based on ISO 31000:2009 on risk management and for determination of delayed variables, the requirements of process groups according to ISO 21500:2013 on project management were used.

Keywords: risk, fishbone diagram, RFMEA, ISO 31000, ISO 21500

1. Introduction

The lifestyle of society that continues to develop in the following times results the government to develop in order to adjust the needs of the community. For the example is construction of road infrastructure. The development needs to be done, because it is estimated that the number of motor vehicle ownership will increase every year. Which is will causes congestion if the available road isn't adequate.

One of the road construction example that expected to cause traffic congestion is on Jatingaleh, Semarang, Central Java. According to kompas.com, Jatingaleh road which is only 1.5 km long takes about 20 minutes to pass through. Finally, Semarang city's government issued a policy to undertake Jatingaleh underpass development project. Properly on June 18th 2015, the parties involved in this project signed the contracts.

The initial agreement for the project was completed on October 13th 2016, but the project was unable to comply the targets of the contract. The extension of PHO (Provisional Hand Over) is until December 15th 2016. However, still cannot be resolved and finally renewed until July 31th 2017. Delay in completion of the project shows the fact that the implementation has not prepared yet in facing the



risks may occur. Therefore it is necessary to perform a risk management that embraces the process of risk management of ISO 31000 with the addition of ISO 21500 (Project Management). Where in conducting risk analysis using the method Project Risk Failure Mode and Effects Analysis (RFMEA) and in forming appropriate recommendation tool made fishbone diagram which will discuss the factors of delay. Therefore, this study is expected to manage the risks that occur in road infrastructure projects in order to ensure that what has been planned in the implementation of a project can run smoothly so as not to cause further delays.

Based on preliminary studies that have been done, it was found that the improvement of infrastructure is indeed needed (such as Jatingaleh underpass development project). In fact there is a delay in the settlement. Factors that cause delays can be seen by observing man power, machine, environment, finance, method, and material. So we need to identify and assess risk that can overcome the delays in infrastructure projects in general. 18

The purpose of this research is to know the factors causing the delay of infrastructure project, to know the state of project risk management and to provide general prevention advice to be used on the upcoming infrastructure projects.

2. Methods

Research methodology is used as a reference in conducting research. This methodology contains the research flow, data collection techniques, research variables, and data analysis.

2.1 Research Flow

This study was initiated by conducting preliminary studies on the object of research. After that, make the formulation of the problem in accordance with the field studies and existing literature. Followed by the determination of research objectives. After the goal set, research continued with the data collection and processing which adopted risk management process according to ISO 31000. Where the first step are communicating and consulting with stakeholder, then making the context setting with fishbone to find out the root of existing problem, and making the risk assessment by spreading the questionnaire which will be processed according to RFMEA method. The RFMEA process is done as follows.



Figure 1. This figure explains the steps of RFMEA.

However, in this study the eighth step is not implemented because there are limitations in this research. And the last is treating the risks. After the data processing has been done then proceed with the data analysis to determine the response of the mitigation that allows to be applied. But, before the recommendations are made it is necessary to verify and validate the selected mitigation facilities so they can be applied to upcoming infrastructure projects.

2.2 Research Variables

This study required variables associated with project activities in accordance with ISO 21500 to determine the risk event categories that occur, such as (ISO, 2013):

Table 1. Definition of some variables that used in this research.

Variable	Definition
Initiating	Undertaken Activities in defining the project
Planning	Activities undertaken when detailing and planning project goals
Implementing	Activities integrate all required resources by implementing what is already planned
Controlling	Activities undertaken to periodically measure and monitor the progress of the project and also to identify whether there any abuse of the implementation of the planned plan

3. Result and Discussion

Based on the data collection that has been done, the following data processing along with the recommendations to be used were obtained.

3.1 Identification of Root Causes

Based on the results of the reference factors causing the delay, this research obtained the description of fishbone as follows.

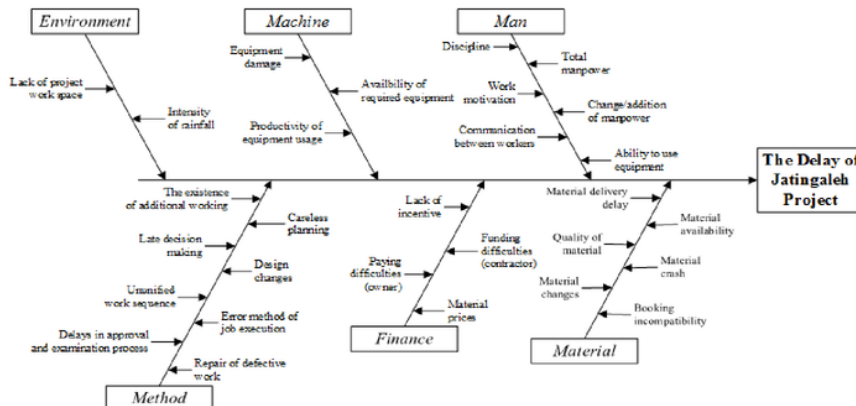


Figure 2. Fishbone Diagram shown the factors can caused the delay of Jatingaleh Project.

3.2 Identification of Risk with RFMEA

By adopting the RFMEA process [1], the risk score was obtained based on the multiplication of likelihood with impact. Here are the pareto results for the risk score on the Jatingaleh project.

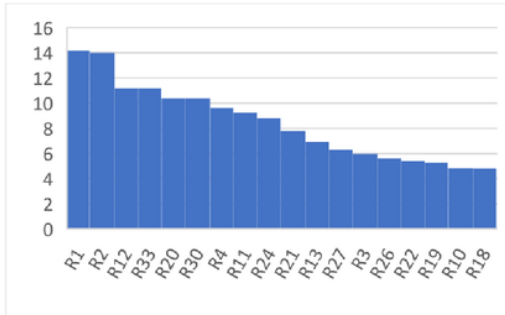


Figure 3. Shown the pareto of Risk Score

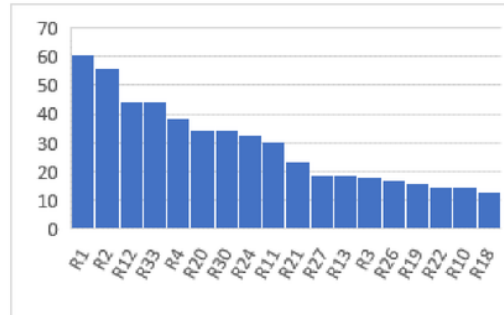


Figure 4. Shown the pareto of RPN

In Figure 3, it was found that R1 is the risk with the highest risk score value. In accordance with the pareto risk score (RS) results, critical value was selected to identify the most important risk on the project. In a study conducted [5], it was stated that there was no systematic procedure in determining criteria for critical RS values as noted [1]. Comparing the maximum value recorded can be done to determine the critical value of Risk Score. Based on existing pareto results, the maximum risk value is almost 0.4 times than early studies [1], where the critical value is 20. So the critical value that selected for this study is 8.

Next step is add a third factor to each risk in the risk list, i.e. detection. Followed with, multiplication between RS with detection value for each Risk ID to obtain Risk Priority Number (RPN) value. As with RS, a pareto chart is created using existing RPN values as follows.

Similar to RS, critical value for RPN in Figure 4 is also needed to identify the most important risks in this project. The determination of critical RPN value is also not explained in detail in the previous studies [5]. Based on the existing RPN pareto, the selected RPN critical value is 31.25. The value is selected based on the maximum RPN value in this study which is considered to be about 0.25 times the maximum value of RPN in early studies [1].

The RFMEA technique introduces a way of prioritizing risk by using two attributes, the RS and RPN attributes. By creating a scatter diagram where the X axis plots the RS and Y axes plots the RPN value, the major risk on the project can be visually identified and it provides a stronger priority mechanism. This scatter diagram shows all the risks that have RS and RPN values greater than the predetermined critical value (the risk that is in the top right quadrant on the scatter diagram). So values RS and RPN are described as follows.

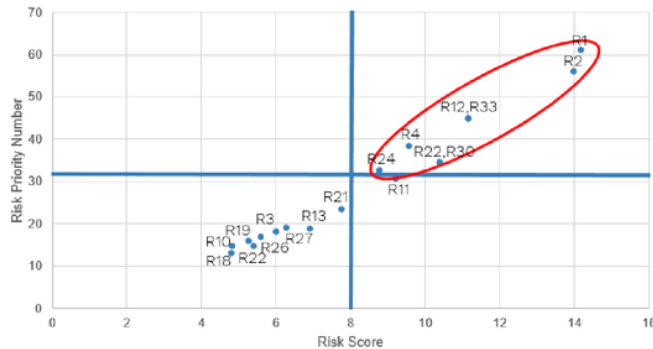


Figure 5. This figure shown the distribution of risk event based on results of matrix RPN vs Risk Score

After obtaining the intersection point between the RS and RPN critical values, it can be found that R1, R2, R4, R12, R20, R24, R30, and R33 are in the red circle on the scatter diagram (Figure 5) and categorized as project risk with highest priority countermeasures. And the final step in the RFMEA process for this research is developing a response plan to address the identified key project risk that will be discussed further in next subsequent chapter.

3.3 Analysis of Data Processing Results

The result of data processing that has been done is adjusted to risk management process at ISO 31000 as follows.

- Communicate and consult
Based on the results of communications and consultations that have been done, the element arrangement that causes the project risk is obtained. Using the previous research, a list of project risk elements that usually occurs in road infrastructure research is acquired. The list is screened to obtain the relevant project risk in Jatingaleh project. This research used 4 process group according to ISO 21500 as category of project risk group. And 37 elements of project risk that may occur in the Jatingaleh project.
- Establish Context using Fishbone Diagram
Context establishing needed to be done to identify and uncover the objectives which this research wants achieve, to assess the nature and complexity of the risks. Based on the results of the discussions that have been done, the results conclude that the method factor is the root of the main problems of project delays. Inadequate planning, uncooperative work sequences and errors in the method of job execution which are the causes of method factors slow down the completion of the Jatingaleh project.
- Project Risk Assessment (RFMEA)
Appropriate with ISO 31000 process, risk assessment process is carried out by method of Project Risk FMEA (RFMEA). The way of processing data using RFMEA method itself is by assessing the risk score and risk priority number on each risk event. The next step is creating pareto for each category of assessment, in order to get the critical value for each category of assessment. Determining the critical value for the risk score and the RPN is followed by placing risk events in each quadrant according to the value of risk scores and existing RPN.
- Treat Risks
Based on the results of data processing with fishbone diagram, it is found that the means of countermeasures that allow to be recommended is making a SOP. Where the SOP recommendation's title is addressed to resolve the critical risks that exist in the critical area of risk score vs RPN matrix of RFMEA method. From the results of data processing with RFMEA there are 8 critical risks for this Jatingaleh project. In order of importance level to be addressed immediately are R1, R2, R12, R33, R20, R30, R4, R24. However, since this study also has restrictions, R1 and R2 can be eliminated because the risk handling is beyond the boundary control of the researcher. So obtained R12, R33, R20, R30, R4 and R24 that allows to be used as SOP title. By considering the value of risk scores and existing RPN, R12 and R33 share the same value and based on the discussion that has been done, R33 is agreed to be prioritized compared to R12. Because R33 concerns the association with groups outside the contractor, consultant and project owner, it will spend longer consolidation time compared to R12 which have links within the internal group of contractor, consultant and project owner. Therefore, possible critical risks are treated by establishing SOP related to the settlement of risks concerning the existence of utilities owned by PLN, PDAM, Telkom which interfere with this project. This recommendation is also made in general, that later this SOP can be used on other road infrastructure projects to prevent any further delays.
- Monitoring and Review
This stage is done after the risk treatment has been determined and implemented. if the chosen treatment after being implemented is not appropriate or useful to overcome the critical risk, it

needs to be reviewed. So, the step of establish context until risk treatment need to be checked again. However, due to the limitations in this study, the researcher did not carry out this stage and fully submitted the results of risk behavior recommendations to the project owners, consultant and contractor for monitoring and review.

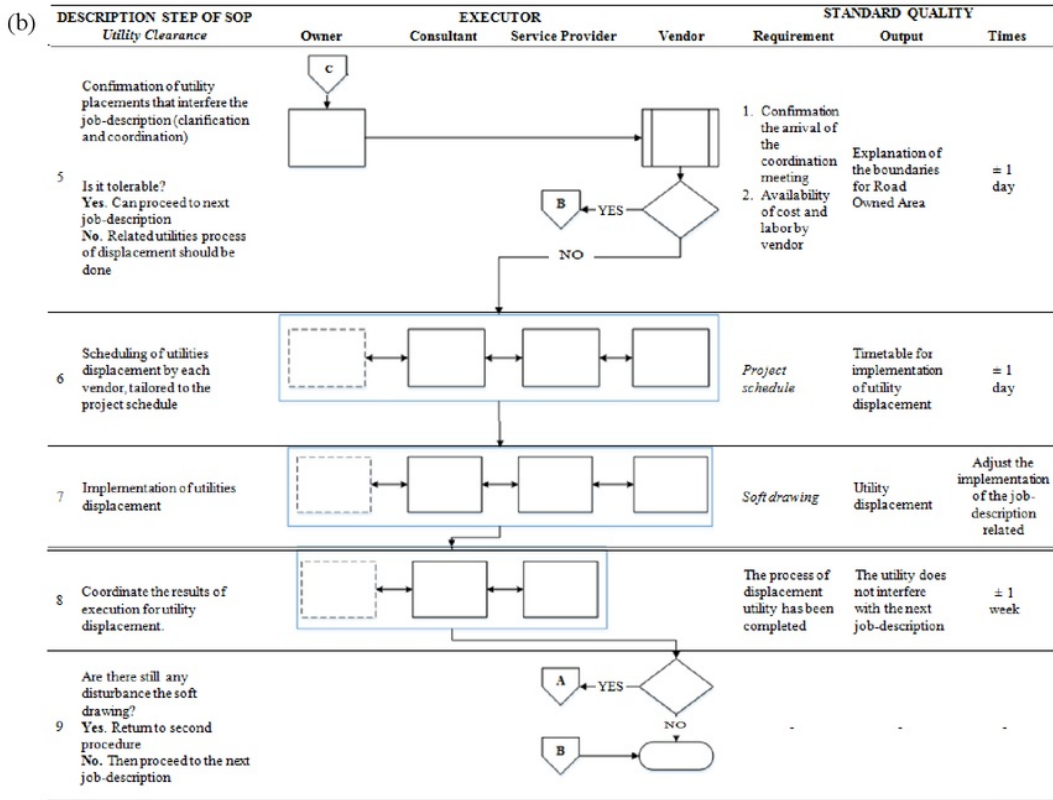
3.4 Designing Standard Operating Procedure
Then the result of SOP design as follows.

Table 2. A head table for SOP Recommendation

Utility Clearance XYZ Project		SOP Number
		Revision Number
		Effective Date
		Approved By
		SOP Names
SOP DESCRIPTION		Utility Clearance
SOP Utility Clearance is a guide used by infrastructure project implementers to handle utility problems that interfere with project completion.		QUALIFICATION AND LIST OF IMPLEMENTATIONS
The Purpose of this SOP is to guide the problem solving to be as effectively and efficiently as possible, with an asset record and also directed and completed information		IMPLEMENTERS
LINKAGES		<ul style="list-style-type: none"> • Owner • Contractor • Consultant • Vendor (related)
To assist in the rapid handling of related utilities that disrupt the implementation of road infrastructure development projects		EXECUTOR QUALIFICATION
REFERENCES		<ul style="list-style-type: none"> • Good technical and interpersonal skills • The ability to cooperate and coordinate with other parties • A good communication techniques • A broad understanding and knowledge about the development of road infrastructure and the placement/removal of road utilities
<ul style="list-style-type: none"> • SNI 03-2850-1992, Tata Cara Penempatan Utilitas di Jalan • Pd. T-13-2004-B, Pedoman Penempatan Utilitas pada Daerah milik Jalan • Peraturan Menteri PU no. 20/PRTM/2010 Pasal 43, Pemindahan dan Pembongkaran 		EQUIPMENTS / REQUIREMENTS
WARNING		<ul style="list-style-type: none"> • Permit for removal of utilities form • Disturbing utilities form
<ul style="list-style-type: none"> • If this SOP is not implemented, then the handling related to the disruption of utility placement on the road infrastructure project will be delayed. • Delayed handling will impact the disruption of operational implementation of the project 		RECORDING
		<ul style="list-style-type: none"> • Note the requirement of standard quality according to step • Note detail the required of standard quality

Table 3. The description of SOP Recommendation

(a)	DESCRIPTION STEP OF SOP Utility Clearance	EXECUTOR				STANDARD QUALITY		
		Owner	Consultant	Service Provider	Vendor	Requirement	Output	Times
1	Comparing the soft drawing to real condition on project					Soft drawing project	Field Engineering	± 2-4 weeks
2	Are there any utilities that interfere with soft drawing execution? Yes. Coordinate for displacement of related utilities. No. Can proceed to next job-description					Field Engineering	List of utilities that interfere with soft drawing	-
3	Conduct a coordination meeting about the name of utilities that interfere the job-description					List of utilities that interfere with soft drawing	Inventory constraints on the field	± 1-2 days
4	Giving invitation regarding coordination meetings for displacement of the utilities to vendors (per-sector/ individual) which interfere the job-description					Removal License	Meeting invitations with related vendors	± 1-5 days



3.5 SOP Examination

After obtaining SOP recommendation, the next step is examination against SOP submitted. The goal is to ensure that the designed SOPs can be used and implemented. So it is necessary to do verification and validation test by giving one scenario in each test, as follows.

Table 4. Shown the SOP Examination in this research

(a)	GOAL	METHOD	AIM
Scenario I	Verify related documents, to prove the truth of the information contained in the SOP-utility clearance	Interview	<ul style="list-style-type: none"> • Owner • Consultant

(b)	GOAL	METHOD	AIM
Scenario II	Validate related documents to see if the SOPs can run under existing conditions and to find out the shortcomings of the proposed SOP to be improved then applied.	SOP simulation and survey	Implementing SOP, i.e.: <ul style="list-style-type: none"> • Contractor • Owner • Consultant

4. Conclusion

This study discusses how to overcome the existing problems in road infrastructure projects, especially those causing delays in project completion. The selected countermeasures of mitigation results a SOP recommendation. The provisions of the SOP title obtained from the critical risks that need to be addressed immediately in this Jatingaleh project, namely the utilities that interfere the project work. The selected recommendation, namely general SOP utility clearance that later can be used for other infrastructure projects.

From the result of this research, it is expected further research can conduct similar research by solving other critical risks, using likelihood assessment based on direct data results, and discuss the results of implementation of SOP utility clearance.

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