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EVALUATION OF THE APPLICATION OF RISK ASSESSMENT IN THE PROJECT "PRESERVASI JALAN DAN JEMBATAN SURABAYA – SIDOARJO" USING THE MONTE CARLO SIMULATION METHOD

Ravniar Kunaifi, Wisnumurti, Achfas Zacoeb

Universitas Brawijaya, Indonesia

*Corresponding Author:
Ravniar Kunaifi

Abstract.

According to the International Labor Organization (ILO), there are 337 million work accidents in various countries which result in around 3 million workers losing their lives every year. So an evaluation of the application of risk was carried out on the "Preservasi Jalan dan Jembatan Surabaya - Sidoarjo". ***Methods:*** *In this research, to analyze the level of risk on the project, the Monte Carlo simulation method was used. Primary data used in this research includes interviews with informants consisting of twenty-three informants from top management and technicians. Secondary research data includes work safety plan documents for the "Preservasi Jalan dan Jembatan Surabaya - Sidoarjo" project. Risk assessment is carried out by determining the level of severity and frequency using a risk analysis matrix. Data processing techniques and work safety analysis are based on analysis documents and interviews, while the table risk analysis is based on the Minister for Publics Work and Housing Regulation No. 10 of 2021.* ***Results:*** *Based on the results of the research that has been carried out, from the 31 indicators, 4 indicator is high risk assessment, 24 indicator is medium risk assessment, and 3 indicator is low risk assessment.*

Keywords*: Risk, Risk Management, Monte Carlo Simulation Method*

INTRODUCTION

Every year thousands of accidents occur in the workplace which can cause loss of life, material damage and production disruption. According to the International Labor Organization (ILO), there are 337 million work accidents in various countries which result in around 3 million workers losing their lives every year. [1]

Based on data from the Employment Social Security Administering Agency (taken from www.bpjsketenagakerjaan.go.id), the number of work accidents in 2019 was 182,835 cases, in 2020 there were 221,740 cases, and 234,270 cases throughout 2021. Work accidents on construction projects in 2021,

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namely 26% in East Java, 22% in Sumatra, 11% in West Java, 11% in Jakarta, 11% in Banten, 5% in Sulawesi, 5% in Central Java, 1% in Yogyakarta, 4% in Kalimantan, 3% in Bali, NTT and NTB and 1% in Papua. Based on this data, it proves that work accidents, especially in the construction sector in the East Java area, are still considered very high, so various efforts are made by contractors as service providers to avoid or reduce risks so that effective results can be achieved. [2]

However, with the high number of work accidents, the Minister for Public Works and Housing is also increasingly improving itself with the issuance of Regulation of the Minister for Public Works and Housing No. 10 of 2021 concerning Guidelines for Construction Safety Management Systems where these guidelines are part of the construction work implementation management system to ensure the realization of Construction Safety. Construction safety itself is defined as all engineering activities to support construction work in realizing security, safety, health and sustainability standards that guarantee the safety and health of public safety workers, property, materials, equipment, construction and the environment. [3]

In general, risk in a project is determined by two factors: the likelihood of an adverse event or outcome, and the severity or cost of the event or outcome. To avoid or reduce the potential costs associated with an adverse event or consequence, the first step is to identify the adverse event and the likelihood of that event and its associated impacts. [5]

The following work accidents often occur on construction projects [4].

a. Slip and fall.
b. Falling objects from above.
c. Trampled.
d. Being hit by a collapsing/collapsing object.
e. Contact with hot and cold temperatures.
f. Falls and rolls.
g. Pinched and crushed.
h. Crashing.
i. Hit hard.

The purpose of risk evaluation in this research is to evaluate the risk level of the construction safety management system based on Regulation of the Minister for Public Works and Housing No. 10 of 2021 on the “Preservasi Jalan dan Jembatan Surabaya – Sidoarjo” project using the Monte Carlo Simulation method.

The Surabaya – Sidoarjo national road section is the connecting road from Sidoarjo to the city of Surabaya. The city of Surabaya is the capital of East Java Province. The “Preservasi Jalan dan Jembatan Surabaya – Sidoarjo” project is a road and bridge repair and improvement work project on the National Road with

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a scope of supervision in the Surabaya - Sidoarjo area, with six handling sections and three bridges.

METHODS

The method used in this research is the Monte Carlo simulation method with quantitative risk assessment adopted in this research by collecting primary and secondary data. Secondary data was obtained from construction safety plan documents for the project "Preservasi Jalan dan Jembatan Surabaya – Sidoarjo". In this research, the evaluation of the application of risks to the work safety management system contains an analysis of hazards and risks arising from potential dangers in a job to evaluate hazards in construction projects. The next step is to carry out a risk assessment from primary data obtained from interviews with informants.

The informants in this research were seven service users, five supervisory consultants, and eleven service providers. The variables in this research include the type of work on the "Preservasi Jalan dan Jembatan Surabaya – Sidoarjo" project, namely earth excavation work, asphalt pavement excavation work with a cold milling machine, emulsion spreading work, hotmix spreading work, formwork installation work, sidewalk casting work, formwork dismantling work, grouting work, and guard rail painting work. The risk indicators used are based on the variables in this research, namely thirty-one risk indicators.

Risk assessment is carried out by determining the level of frequency and severity using a risk analysis matrix. Data processing and analysis techniques are based on secondary data, observation and interviews. The risk level is obtained from the risk analysis table based on Regulation Minister of Public Work and Housing No. 10 of 2021 in Table 1. In carrying out a risk assessment, it is necessary to first determine the frequency criteria and severity criteria. Frequency criteria include events that almost never occur, are unlikely to occur, are likely to occur, are very likely to occur, or are almost certain to occur. Severity criteria can be categorized as barely severe, not severe, moderately severe, severe, or nearly very severe. After determining the frequency and severity criteria, the risk level for the project "Preservasi Jalan dan Jembatan Surabaya – Sidoarjo" is determined through the risk matrix in Table 1. The frequency and severity criteria are listed in Tables 2 and 3 respectively.

Table 1. Risk Matrix

	Severity				
Frequency	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Source : Minister for Public Works and Housing Regulation Number 10 of 2021.

Table 2. Frequency Criteria

Frequency Level	Description	Definition
5	Almost Certain to Happen	There is a high possibility of an accident occurring while doing work
		The possibility of accidents occurring more than 2 times in 1 year
4	Very possible	The possibility of an accident occurring while doing work in almost
		The possibility of an accident occurring once in the last 1 year
3	Might happen	It is possible that accidents will occur when carrying out work in
		The possibility of an accident occurring 2 times in the last 3 years
2	Small Chance of Happening	There is a small chance of an accident occurring when carrying out work under certain conditions
		The possibility of an accident occurring once in the last 3 years
1	Almost Never Happens	Accidents can occur while doing work under certain conditions
		The possibility of an accident occurring more than the last 3 years

Source : Minister for Public Works and Housing Regulation Number 10 of 2021.

Table 3. Severity Criteria

Severity Level	Description	Safety Consequences Scale			Public Environment/Facilities
		Human (Workers & Society)	Equipment	Material	
5	Almost Very Severe	The occurrence of fatalities is more than 1 person dies; or More than 1 person with permanent disability	More than one major piece of equipment was completely damaged and caused work to stop for more than 1 week	The material is damaged and new material needs to be brought in which takes more than 1 week and causes work to stop	Causing air/water/land/noise pollution which results in complaints from the public; or
					There is environmental damage in National Parks related to flora and fauna; or
					Damage to surrounding community assets as a whole
					There was serious damage to community road access
					There was a traffic jam for more than 2 hours
4	Critical	The occurrence of fatalities is more than 1 person dies, or 1 person with permanent disability	More than one major piece of equipment was completely damaged and caused work to stop for 1 week	The material is damaged and new material needs to be brought in which takes 1 week and causes work to stop	Causing air/water/land/noise pollution which results in complaints from the public; or
					There is environmental damage related to flora and fauna; or
					Damage to some of the assets of the surrounding community
					There was damage to some community road access
					There was a traffic jam for 1-2 hours
3	Quite Severe	There was an incident that resulted in more than 1 worker receiving inpatient medical treatment, losing work time	There was more than one piece of equipment that was damaged and required repair and resulted in work stopping for less than seven days	The material is damaged and new material needs to be brought in which takes more than 1 week and does not result in the work stopping	Causing air/water/soil/noise pollution that affects the work environment; or
					There is environmental damage related to plants in the work environment; or
					There was damage to road access in the work environment
					There was a traffic jam for 30 minutes - 1 hour
2	Not Severe	There was an incident that resulted in more than 1 worker receiving inpatient medical treatment, losing work time	One piece of equipment was damaged, requiring repairs and causing work to stop for more than 1 day	The material was damaged and needed to bring in new material which took less than 1 week, but did not result in the work stopping	Causing air/water/soil/noise pollution that affects parts of the work environment; or
					There was damage to part of the access road in the work area
					There was a traffic jam for less than 30 minutes
1	Almost Not Very Severe	There are incidents that are handled only through first aid, without losing work time	One piece of equipment was damaged, requiring repairs and causing work to stop for less than 1 day	Does not cause material damage	Does not cause environmental disturbances

Source : Minister for Public Works and Housing Regulation Number 10 of 2021.

RESULT

Monte Carlo is a method for analyzing the development of uncertainty. The steps used are to obtain the standard deviation value according to the data, namely 235. Then determine the margin of error, namely 19. So the number of iterations required is 1436 iterations. After iterating 1436 times with the Monte Carlo simulation process in figure 1 and 2, also results as shown in table 4.

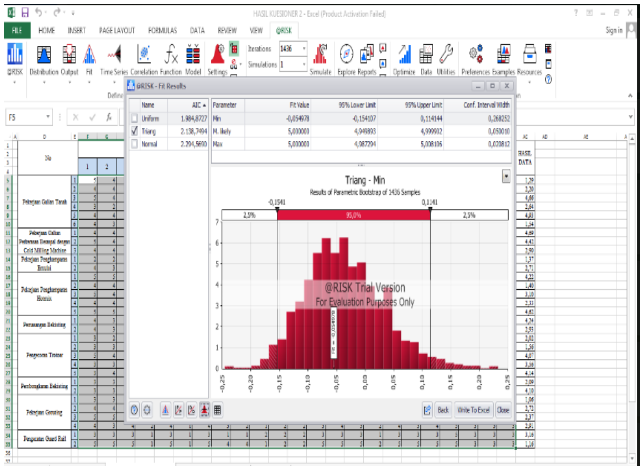

Figure 1. Results of Application of Monte Carlo Simulation to frequency.

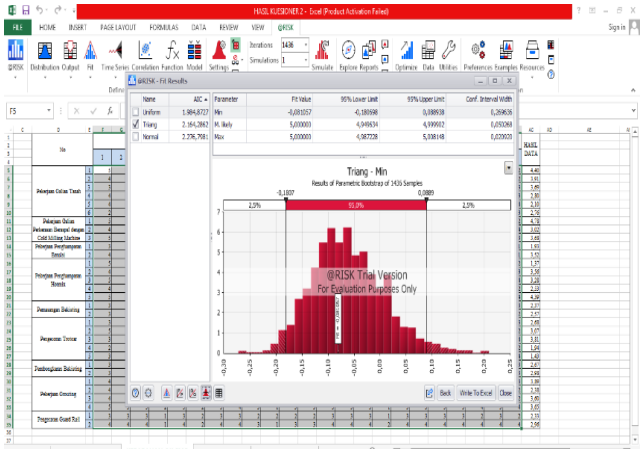

Figure 2. Results of Applying Monte Carlo Simulation to severity.

Table 4. Monte Carlo Simulation Results @1436 iterations on frequency and severity.

Type of work		Risk Indicators		Frequency	Severity
1	Earth Excavation Work	1	Fell from the excavator	1,29	4,40
		2	Fell into the excavation	2,20	3,91
		3	Exposure to soil excavation dust	2,06	3,69

		4	Tools injure other parts of the worker's body	2,64	2,80
		5	Heavy equipment damage	4,93	2,10
		6	Pedestrians fell into excavations on the sidewalk	1,54	2,76
2	Asphalt Pavement Excavation Work with Cold Milling Machine	1	Fell from a cold milling machine	4,69	3,78
		2	Exposure to dust from asphalt excavation debris	4,42	3,02
		3	Passing vehicles fell into asphalt excavations	2,90	3,68
3	Emulsion Spreading Work	1	The worker slipped while spreading the emulsion	1,37	1,93
		2	Hands exposed to emulsion when spraying emulsion	2,71	3,52
4	Hotmix Laying Work	1	The worker's hand was injured due to exposure to hot asphalt	4,22	4,37
		2	Workers are exposed to irritation of the respiratory tract due to chemical exposure from high-temperature asphalt	1,40	3,56
		3	Injured due to careless use of the tandem roller and tire roller	3,10	3,28
		4	Workers suffer from eye irritation due to exposure to high temperature asphalt	2,33	2,53
		5	The worker was hit by a passing vehicle	4,62	4,39

5	Formwork Installation Work	1	Hands scratched by wood chips due to formwork installation	4,24	2,37
		2	The worker was crushed by the wooden formwork due to the wooden formwork falling during the mobilization of tools	2,93	2,57
6	Pavement Casting Works	1	Injured due to careless use of tools	2,02	2,68
		2	The vibrator touches parts of the worker's body	1,56	3,07
		3	Skin irritation due to skin contact with concrete	2,07	3,81
		4	Respiratory problems due to exposure to concrete chemicals during casting	3,56	1,94
		5	Pedestrians fell into the concrete cast when the concrete was not yet dry	4,14	1,43
7	Formwork Dismantling Work	1	Workers were scratched by wood chips as a result of dismantling formwork	2,09	2,67
		2	The worker was crushed by wooden formwork as a result of raising the wooden formwork when demobilizing tools	4,10	2,98
8	Grouting Work	1	Irritation from exposure to chemicals	1,06	3,89
		2	Electric shock when using an electric drill	2,72	2,38

		3	Tripping over cables or other materials	2,37	3,60
		4	Falling from a height	2,91	3,65
9	Guard Rail Painting Work	1	Injured due to careless use of tools	3,16	2,33
		2	Hit by a passing vehicle	1,16	2,96

What will be simulated is a project consisting of nine types of work with 31 risk indicators. By collecting primary data by distributing questionnaires to seven service users, five supervisory consultants, and eleven service providers, then data processing was carried out using the Monte Carlo simulation method. Then, data analysis is carried out by providing an assessment of the risks in the risk assessment matrix. After obtaining the results from the iteration of the Monte Carlo simulation method, data analysis was then carried out by providing an assessment of the risks in the risk assessment matrix in accordance with table 5, as follows:

Table 5. Risk Assessment

Type of work	Risk Indicators	Frequency	Severity	Risk Assessment	
1	1	1,29	4,40	5,67	Medium
	2	2,20	3,91	8,63	Medium
	3	2,06	3,69	7,59	Medium
	4	2,64	2,80	7,39	Medium
	5	4,93	2,10	10,38	Medium
	6	1,54	2,76	4,26	Medium
2	1	4,69	3,78	17,71	High
	2	4,42	3,02	13,36	High
	3	2,90	3,68	10,67	Medium
3	1	1,37	1,93	2,65	Low
	2	2,71	3,52	9,54	Medium
4	1	4,22	4,37	18,45	High
	2	1,40	3,56	4,98	Medium

	3	3,10	3,28	10,18	Medium
	4	2,33	2,53	5,88	Medium
	5	4,62	4,39	20,26	High
5	1	4,24	2,37	10,02	Medium
	2	2,93	2,57	7,53	Medium
6	1	2,02	2,68	5,43	Medium
	2	1,56	3,07	4,81	Medium
	3	2,07	3,81	7,88	Medium
	4	3,56	1,94	6,92	Medium
	5	4,14	1,43	5,94	Medium
7	1	2,09	2,67	5,60	Medium
	2	4,10	2,98	12,23	Medium
8	1	1,06	3,89	4,13	Low
	2	2,72	2,38	6,49	Medium
	3	2,37	3,60	8,52	Medium
Type of work	Risk Indicators	Frequency	Severity	Risk Assessment	
	4	2,91	3,65	10,60	Medium
9	1	3,16	2,33	7,36	Medium
	2	1,16	2,96	3,43	Low

The results above for a total of 31 hazards in 9 jobs from the table above were converted into percentages, so the following results were obtained are 4 indicator is high risk assessment, 24 indicator is medium risk assessment, and 3 indicator is low risk assessment.

CONCLUSION

The purpose of risk evaluation in this research is to evaluate the risk level of the construction safety management system based on Regulation of the Minister for Public Works and Housing No. 10 of 2021 on the "Preservasi Jalan dan Jembatan Surabaya – Sidoarjo" project using the Monte Carlo Simulation method. Based on the results of the research that has been carried out, from the 31 indicators, 4 indicator is high risk assessment, 24 indicator is medium risk assessment, and 3 indicator is low risk assessment.

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