



Research Paper

## Analysis of Occupational Safety Risk Management on SelangDam Rehabilitation Project in the Selang Irrigation Area, Pasuruan Regency – Indonesia

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**Abstract:** A dam rehabilitation project is a type of construction project with high level of occupational safety risk, in particular when executed in such locations with difficult terrain condition, steep slopes, and get affected by natural factor such as extreme weather and potential flooding. The Selang Dam Rehabilitation Project is conducted in Selang Irrigation area that located in Wonosari subdistrict, Gempol District, Pasuruan Regency of East Java Province. It is a strategic project which plays essential role in supporting irrigation system and regional food security but has potential to have significant occupational safety hazard. This study aims to identify potential occupational safety hazard, determine highest level of occupational safety risks and analyze risk control efforts in Selang Dam Rehabilitation Project.

Research method in this study was a semi-quantitative method based on AS/NZS 4360:2004. Research data were obtained through field observations, interviews, and questionnaires distributed to 35 respondents with different work background (project management, consultant, OHS officer, and field workers). Risk assessment is carried out by multiplying the likelihood and consequences values to obtain a risk index which later will be classified into low, moderate, high and very high risk categories.

Result of this study indicates there are number of occupational safety risks that categorized into high and very high risk level found in preparatory work, earthwork, dam concreting work, mason stone installation work, and dewatering work. While dominant risks identified are include worker falling from high place, hit by falling material or landslide, swept away by river current and injuries due to the use of work tool and heavy equipment. Recommended risk control efforts include consistency in implementing Construction Safety Management System (SMKK), increased field supervision, provision and use of Personal Protective Equipment (PPE), implementation of safe work procedures, and increasing worker awareness and competence through OHS training.

**Keywords:** Risk management, work safety, AS/NZS 4360:2004, rehabilitation project.

### I. INTRODUCTION

SelangDam located in Wonosari Village, Gempol District of Pasuruan Regency, East Java Province is a Dutch heritage dam used for irrigating area of 144 hectares and having high historical value also strategic function for agriculture irrigation. In December 2021, the dam experienced damage due to excessive water discharge from KambingRiver, resulting damages in its lighthouse, downstream floor and downstream right wing of the dam. Since the location is difficult to reach (located at altitude of 50 m from riverbed with 70 % slope inclination, extreme weather and potentiality of flash flood) make rehabilitation process becomes very complex and possessing a high-risk level. Without rehabilitation, disruption to irrigation system will bring negative impact to crop failure, reduced food production and economic losses for farmers, thus, threatening regional food security.

Rehabilitation project for SelangDam is a strategic regional project funded by financial grant from National Disaster Management Agency (BNPB) as commanded by Minister of Finance through regulation number 29 of 2024. Its implementation requires significant financial resources, labor also equipment, so the interaction between these resources bring potential to create various risks particularly in scope of construction accidents. This risk is further increased by steep topography and closeness nature of the location to industrial area, which brings further risk to the safety of workers and heavy equipment in the related area. Therefore, an implementation and optimization of Construction Safety Management System (SMKK) play a crucial role, in particular for the concrete work at the dam floor and wings for identifying potential hazards and prevent workplace accidents in accordance with PUPR Ministerial Regulation Number 10 of 2021. [1,2]

Research by Priyanto et al., conducted a work accident risk analysis in main dam and embankment work of Jragung Dam by AS/NZS 4360:2004 method had successfully identified 15 work accident risks with 13 % was included into low risk, 27 % was included into medium risk, and 60 % was included into high risk which indicates the main dam embankment work has very large potential for work accidents. In line with this research, Ahya et al. analyzed work accident risk management in a concrete bridge construction project with the AS/NZS 4360:2004 standard able to identify 31 risk variables, where the dominant risks based on the Pareto principle (include workers being hit by materials or equipment from a height, workers falling from a height, girders falling during the erection process, equipment falling from a height, piles falling, workers being cut by tools while cutting iron, and the risk of earthen walls collapsing) with overall result confirms the existence of high level of work accident risk in large-scale construction projects. [3,4]

According to the background of this study, then the following research questions are formulated:

1. How are the occupational safety hazards identified in Selang Dam Rehabilitation Project in Pasuruan Regency?
2. What is the highest occupational safety risk in Selang Dam Rehabilitation Project in Pasuruan Regency using the AS/NZS 4360:2004 method?
3. How to control the occupational safety risk in Selang Dam Rehabilitation Project in Pasuruan Regency?

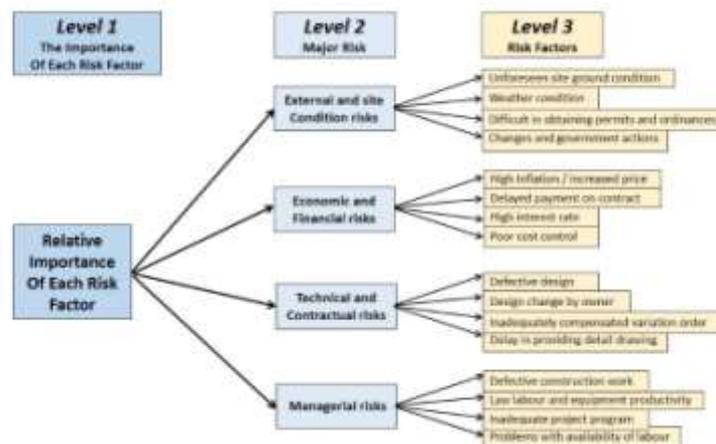
## II. LITERATURE REVIEW

### 2.1. Dam/Weir

A dam is a construction made from river stones or coral stones, gabions or concrete, which is located across a river and functions to raise the water level for irrigation purposes.

### 2.2. Risk Management in Construction Project

The definition of risk in a construction project is a description of the unfavorable consequences, both financially and physically, resulting from decisions taken or from environmental conditions at the location of an activity. Furthermore, Efrizon states that risk in a construction project is matter that cannot be eliminated, but its impact can be minimized. [5]



**Figure 1.** A risk hierarchy in construction project

According to Gray and Larson, risk management process consisting of four processes phase [6]:

1. Risk Identification. Analyzing the project to identify source of risks.
2. Risk Assessment. Assessment to the impact, likelihood of occurrence and control measures.
3. Response Development to the risks. Developing response to the risk, including mitigating potential damage and developing contingency plan.
4. Response control to the risks. Controlling the response to the risks, including improving the risk strategy, monitoring and adjusting the plan for new risks and implementing changing in management.

### 2.3. Risk Identification

Cause and Effect Analysis is a technique used to study a problem to determine its causes and effects. Problems should be analyzed for their causes and effects until they no longer produce other symptoms. Cause and Effect Analysis leads to a true understanding of the problem and can lead to less obvious, but more creative and valuable solutions. [7]

**2.4. Risk Analysis**

According to The Standard Australia/New Zealand there are 4 (four) steps in risk management procedures [8]:

1. Establish the Context.To define internal and external boundaries or parameters that will be considered and discussed in risk management. It also determines work scope and risk criteria for the next processes.
2. Identify Risk.Risk identification is the phase of obtaining relevant risk variables.
3. Goal of risk identification is developing a comprehensive list of risk sources and occurrences that impact the achievement of goals and targets identified from the context.
4. Analyze Risk.Risk analysis includes consideration of risk sources, consequences, and the likelihood of those risks. Risk is analyzed by combining likelihood (probability or frequency) and consequences (impact or effect) values.

$$\text{Risk Index(Risk)} = \text{Probability} \times \text{Consequences}$$

After the risk index value is calculated, the next step is to group the risk levels based on the matrix table used. This grouping aims to determine whether a risk falls into the Very High (VH), High (H), Moderate (M), or Low (L) category. Determining the risk level is a crucial component of the management decision-making process, as this risk ranking allows management to establish priorities and appropriate management strategies when the risk actually occur.

**Table1.**Risk analysis matrix (level) based onAS/NZS 4360:2004 [8]

Risk Value	Risk Category	Description
1-3	L	Low
4-9	M	Medium
10-16	H	High
17-25	VH	Very High

Description:

- L : Low Risk (low risk, handle with routine procedures)
- M : Moderate Risk (moderate risk, requiring clear management responsibility)
- H : High Risk (high risk, requires special attention from the management)
- VH : Very High Risk (high risk or intolerable and requires immediate treatment)

**2.5. Risk Evaluation**

The purpose of risk evaluation is to facilitate decision-making based on the analysis results. The risk evaluation process determines which risks require treatment and how to prioritize them. This can be done by grouping or classifying likelihood and consequence values into a risk matrix. Once the likelihood and consequence values are known, they can be plotted on the risk matrix to determine the level of risk posed. For detailed explanation, the risk matrix will be presented in the following table (Table 2).

**Table2.**Risk matrix [8]

Impact (Consequences)					
Probability (Likelihood)	(1)	(2)	(3)	(4)	(5)
	Insignificant/ Very small	Small	Moderate	Big	Very Big/ Catastrophic
(A) Very Often	M	H	E	E	E
(B) Often	M	H	H	E	E
(C) Frequent	L	M	H	H	E
(D) Seldom/Rare	L	M	M	H	H
(E) Very Rare	L	L	L	M	M

Description:

- E :Extreme risk, intolerable and needs immediate treatment
- H : High risk, undesirable and only accepted when risk reduction cannot be implemented and requires special attention from the management
- M :Moderate risk, accepted with approval and requires clear accountability from the management
- L :low risk, accepted with approval by the management and can be addressed by routine procedures

The result of the risk evaluation is risk ranking data that requires further handling based on the remaining risks and the effectiveness of existing risk controls.

## 2.6. Identification of Causes of Work Accident Risks

Researchers use the domino method to identify the causes of workplace accident risks. The Heinrich theory, or Domino theory, was first discovered by H.W. Heinrich (Dan Petersen, 1971), as quoted by Wibisana (2016) that stating the most valuable methods for accident prevention are analogous to those needed for quality control, costs, and production quality. The Heinrich Domino Theory by H.W. Heinrich is one of the most well-known theories explaining the occurrence of workplace accidents. In the Heinrich Domino Theory, there are five causes of accidents, including: [9,10]

1. Heredity. Heredity aspect includes the background of an individual, such as lack of knowledge, character of the individual such as stubbornness attitude.
2. Human Error. Human error/negligence includes low motivation, stress, conflict, problems related to the physical condition of workers, inappropriate skills, etc.
3. Behavior and Unsafe Condition. Unsafe attitudes/actions, such as carelessness, not following work procedures, not using personal protective equipment (PPE), not following signs in the workplace, not taking care of hazardous work permits before starting high-risk work, and so on. Meanwhile, unsafe conditions include inadequate lighting, inadequate work tools, no work safety signs, or the lack of complete PPE.
4. Work Accident. Work accidents, such as slipping, burns, being hit by objects in the workplace occur due to contact with sources of danger.
5. Impact of Losses. The impact of losses could be found in forms: 1) Worker: injury, disability, or death; 2) Employer: direct and indirect costs; 3) Consumer: product availability.

These accident causal factors are arranged like dominoes. It means when one card falls, it will fall on top of the other cards. This illustration is similar to famous domino effect: if one building collapses, this incident will trigger a chain of events that cause other building to collapse.

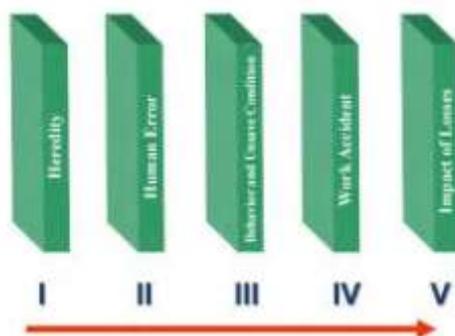


Figure 2. Domino method

Explanation: when one domino falls, it will hit all domino cards, eventually all domino cards will fall entirely (in the direction of the arrow).

## III. RESEARCH METHOD

### 3.1. Data Collection

#### 3.1.1. Primary Data

The primary data in this study consists of potential hazard data related to potential technical risks and work accident risks in the Selang Dam Rehabilitation Project. Primary data were obtained through direct field observations, structured interviews, and risk scale assessments using questionnaires distributed to selected respondents. The questionnaire method used in this study refers to the HIRA (Hazard Identification and Risk Assessment) method with the AS/NZS 4360:2004 standard. The questionnaire was compiled based on the results of field observations, literature studies, and discussions with competent parties, so that each question item represents the real potential hazards that able to occur in each project work item.

Each question in the questionnaire uses a semi-quantitative risk assessment method, which assesses risks based on two main parameters of: (a) possibility of risk occurrence (Likelihood/Probability) and (b) impact or severity of risk (Consequence/Severity) Respondents are asked to provide an assessment of each potential hazard by selecting a predetermined scale value. The likelihood assessment scale refers to the AS/NZS 4360:2004 standard applied with five level of scale ranging from very rare to very frequent, while the impact scale (consequence) also consists of five level scale ranging from insignificant to very large or fatal. Furthermore, risk scoring is done by multiplying the likelihood value and the impact value (consequence) of each question or risk variable through the following formula:

**Risk Score = Likelihood × Consequence**

Result of the calculation will be in form of risk index value which then classified into Low (L), Moderate (M), High (H), or Very High (VH) risk level based on the AS/NZS 4360:2004 risk matrix. This categorization aims to determine priority level of risks that requires further control.

### **3.1.2. Secondary Data**

In this study, the employed secondary data is obtained from the project data as listed in the following description: 1) Work drawing; 2) Technical Specification (RKS); 3) HSE Plan; 4) HIRARC; 5) JSA (Job Safety Analysis); 6) Work Method; 7) Budget Plan (Rencana Anggaran Biaya/RAB); 8) Other related documents to project.

## **3.2. Sample and Population of the Study**

### **3.2.1. Population**

Population is a generalization area that includes objects or subjects with certain qualities and characteristics that have been determined by the researcher (Sugiyono, 2019). The population in this study was 35 individuals involved in the Selang Dam Rehabilitation Project: the head of the Water Resources, Public Works and Spatial Planning Agency, PPK (Commitment Making Officer), head of the UPT SDA Pandaan area, irrigation officers, dam gate guards, consultants, director of CV Anugrah Perdana, field supervisors, K3 officers, foremen, craftsmen, heavy equipment operators and workers. [11]

### **3.2.2. Sample of the Study**

A sample is a sub part of the population's size and characteristics. All risk identification variables are determined based on discussions and interviews and will be assessed based on their probability and impact to determine the risk level. This study used a total sampling method, where all members of the population were sampled. Therefore, the sample size for this study was 35 individuals, the same as the predetermined population size. [11]

## **3.3. Data Analysis**

After obtaining the results of data collection in the form of probability data and consequent data from the distribution of questionnaires and interviews, validity and reliability tests are then conducted to determine whether the results of the data collection (the distribution of questionnaires) is valid and consistent. If all variables are valid, then the validity test data can be processed.

1. **Validity Test.** Validity testing aims to determine accuracy and precision level of an instrument in carrying out its measuring function. Santoso, explains that validity indicates the extent to which a measuring instrument is able to function precisely and accurately. To determine the level of validity of data, it requires an r value that obtained based on the number of respondents. A statement item is considered valid if the calculated r value is greater than the r table. In this study, the validity test was performed using the SPSS 18 program. This test conducted to ensure questionnaire completed by 35 respondents was truly valid and could be properly understood. With a sample size of 35 people, the r table value was 0.334. The r table according to Sugiyono, is listed in Appendix 1. Based on the results of the validity test, it was found that calculated r value has greater value than r table of 0.334, so that all questionnaire items were declared valid. [12,13,14]
2. **Reliability Test.** After validity test is completed, the next stage is checking consistency of the respondents' answers through a reliability test. Reliability indicates the extent to which an instrument is trustworthy and suitable for use as data collection tool, because the instrument has met good quality criteria. In determining whether an instrument is reliable, Sugiyono explains that an instrument is declared to have adequate reliability if its coefficient able to reach minimum value of 0.60. Thus, an instrument can be categorized as reliable if the Alpha value  $\geq 0.60$ , while the instrument is considered unreliable if the Alpha value  $< 0.60$ . In this study, a reliability test was conducted to ensure that the instrument is truly consistent. Referring to Sugiyono (2007), an instrument is considered reliable if the Alpha value is greater than the t-table value, so the questionnaire can be said to have a good level of reliability. [14,15]

## **IV. RESULT AND DISCUSSION**

### **4.1. Risk Identification**

In referring to result of risk identification questionnaire, variables for occupational safety risk that seen as relevant to actual condition in the field were able to be obtained. Result of the occupational safety risk identification survey is presented in the following table (Table 3).

**Table 3.**Result of risk identification survey

No	Type of Work	Activity	Potential Danger/Risk	Code	Relevance
1	Preparatory Work	Uitzet	Worker slips and fall	PS1	Relevant
		Sign board	Hand injury danger from hammering when making Project Information Board	PS2	Relevant
		Rent access road	Worker fell to the ground	PS3	Relevant
		Construct, filling and levelling the access road	Danger of being hit by Dozer heavy equipment	PS4	Relevant
			Dozer slips and sink while spreading soil	PS5	Relevant
			Suffocation danger due to dust	PS6	Relevant
		Box Culvert installation	Danger to body parts being squeeze by box culvert	PS7	Relevant
			Danger of get hit by box culvert	PS8	Relevant
2	Earth/ground work	Cleaning work	In contact with dangerous animal or insect	T1	Relevant
		Land excavation	Worker injured due to the use of hand tool	T2	Relevant
			Danger of landslide because of excavation materials	T3	Relevant
			Danger of drowning due to channel current	T4	Relevant
			Worker hit by digging tool	T5	Relevant
		Pile of soils	Danger of being buried by landslide	T6	Relevant
			Worker gets hit by stamper compacter	T7	Relevant
		3	Concrete work	Ready mixed concrete, quality $f_c = 10$ MPa (K125)	Worker slips or fell
Worker gets hit by falling object/landslide from cliff	B2				Relevant
Ready mixed concrete, quality $f_c = 15$ MPa (K175)	Existing pairing collapse or fall from the cliff			B3	Relevant
	get hit by falling object/landslide from cliff			B4	Relevant
	Skin infection due to concrete chemical			B5	Relevant
	Danger of being swept away by river current			B6	Relevant
Ready mixed concrete, quality $f_c = 20$ MPa (K225)	Worker slips or fell			B7	Relevant
	get hit by falling object/landslide from cliff			B8	Relevant
	Danger of being swept away by river current			B9	Relevant
	Skin infection due to concrete chemical			B10	Relevant
Ready mixed concrete, quality $f_c = 26.4$ MPa (K300)	get hit by falling object/landslide from cliff			B11	Relevant
	Formwork collapse or broken			B12	Relevant
	Worker slips or fell			B13	Relevant
	Skin infection due to concrete chemical			B14	Relevant
Ironing work	Danger for hand and feet get cut by grinder tool			B15	Relevant
	Danger of stabbed by iron			B16	Relevant
	Worker gets hit by falling object/landslide from cliff			B17	Relevant
Concrete floor formwork	Worker gets trapped or pierced by nail that protrudes from formwork			B18	Relevant
	Worker slips or fell			B19	Relevant
	get hit by falling object/landslide from cliff			B20	Relevant
Ready mixed cycloop concrete (concrete 60%, stone 40%)	Danger from falling rock/stone			B21	Relevant
	Danger of hand getting caught in stones			B22	Relevant
	Danger of being hit by concrete			B23	Relevant

No	Type of Work	Activity	Potential Danger/Risk	Code	Relevance
			debris		
			Worker gets hit by falling object/landslide from cliff	B24	Relevant
			Skin infection due to concrete chemical	B25	Relevant
			Danger of swept away by river current	B26	Relevant
			The existing old pairing collapse or ruin	B27	Relevant
4	Mortar stone installation work	Stone installation	Worker exposed to stone material	BM1	Relevant
			Danger of hand get squeezed by rock or stones	BM2	Relevant
			get hit by falling object/landslide from cliff	BM3	Relevant
		Plastering	Respiratory problems due to sand or cement dust	BM4	Relevant
			get hit by falling object/landslide from cliff	BM5	Relevant
		Joint sealing or expansion joint sealing work	Respiratory problem due to dust at channel lining	BM6	Relevant
			get hit by falling object/landslide from cliff	BM7	Relevant
		Pair dismantling	Worker slips or fell	BM8	Relevant
			Worker exposed to rock demolition material	BM9	Relevant
			Worker gets injured because of stone cutter tool	BM10	Relevant
5	Miscellaneous work	Dewatering	Danger of falling into water puddles	LL1	Relevant
			Electric shock because short circuit in water pump machine	LL2	Relevant
		Making cofferdam or temporary damand transporting material	Slipped when lowering the pump hose	LL3	Relevant
			Worker slips or fell	LL4	Relevant
			Danger of being swept away by the river current	LL5	Relevant

#### 4.2. Risk Assessment

The risk assessment process involving 35 respondents where each of them had work competencies and experiences in different work groups of: 1) preparatory work; 2) earthwork; 3) concrete work; 4) mortar installation work; and 5) other work.

The results of the impact assessment are then summarized into a data summary, which shows the variation in impact levels between job types. This data summary is used as a basis for determining risk priorities, allowing high-impact jobs to be identified. The summary of the risk impact levels is shown in the following tables.

##### 4.2.1. Risk Impact on Preparatory Work

Table 4. Recapitulation data of preparatory work assessment result

No	Activity	Danger Potential/Risk	Code	Impact Level					
				1	2	3	4	5	
1	Uitzet	Worker slips and fall	PS1	6	7	8	9	5	
	Sign board	Hand injury danger from hammering when making Project Information Board	PS2	13	15	6	1	0	
	Rent access road	Worker fell to the ground	PS3	6	7	8	9	5	
	Construct, filling and levelling the access road	Danger of being hit by Dozer heavy equipment	Dozer slips and sink while spreading soil	PS4	0	0	7	21	7
			Suffocation/respiratory danger due to dust	PS5	3	7	9	13	3
				PS6	2	12	15	3	3
	Box Culvert installation	Danger to body parts being squeeze by box culvert	PS7	6	7	8	9	5	

		Danger of get hit by box culvert	PS8	0	10	17	5	3
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4.2.2. Risk Impact on Earth Work

Table 5. Recapitulation data of earth work assessment result

No	Activity	Danger Potential/Risk	Code	Impact Level				
				1	2	3	4	5
1	Cleaning (clearing and grubbing)	In contact with dangerous animal or insect	T1	0	9	17	9	0
		Worker injured due to the use of hand tool	T2	3	14	11	5	2
	Ordinary land excavation	Danger of landslide because of excavation materials	T3	0	6	14	14	1
		Danger of drowning due to channel current	T4	0	3	7	19	6
		Worker hit by digging tool	T5	1	11	16	7	0
	Box Culvert Installation	Danger of being buried by landslide	T6	0	5	19	9	0
		Worker gets hit by stamper compacter	T7	0	9	17	9	0

4.2.3. Risk Impact on Concrete Work

Table 6. Recapitulation data of concrete work assessment result

No	Activity	Danger potential/Risk	Code	Probability Level				
				1	2	3	4	5
1	Ready mixed concrete, quality f'c = 10 MPa (K125) using concrete pump (bridge plate)	Worker slips and fall	B1	6	7	8	9	5
		Worker gets hit by falling object/landslide from cliff	B2	1	10	15	5	4
	Ready mixed concrete, quality f'c = 15 MPa (K175) using concrete pump (work floor)	The existing old pairing collapse or ruin	B3	1	10	14	6	4
		Worker gets hit by falling object/landslide from cliff	B4	1	11	14	5	4
		Skin infection due to concrete chemical	B5	0	9	17	9	0
		Danger of being swept away by the river current	B6	6	7	9	8	5
	Ready mixed concrete, quality f'c = 20 MPa (K225) using concrete pump (right wing embankment)	Worker slips and fall	B7	5	8	8	9	5
		Worker gets hit by falling object/landslide from cliff	B8	1	11	15	4	4
		Danger of being swept away by the river current	B9	2	9	13	9	2
		Skin infection due to concrete chemical	B10	6	7	8	9	5
	Ready mixed concrete, quality f'c = 26.4 MPa (K300) using concrete pump (dam/weir floor)	Worker hit by concrete pump pipe hose	B11	1	12	14	5	3
		Formwork collapse or ruin	B12	2	9	13	9	2
		Worker slips and fall	B13	6	10	9	8	5
		Skin infection due to concrete chemical	B14	1	10	17	7	0
	Iron reinforcement with threaded iron	Danger for hand and feet get cut by grinder tool	B15	1	12	16	6	0
		Worker's eyes get fire sparks while cutting iron	B16	1	13	17	4	0
		get hit by falling object/landslide from cliff	B17	2	9	13	9	2

Ordinary concrete floor formwork with 12 mm 18 mm (TP)multiflex	Worker gets trapped or pierced by nail that protrudes from formwork	B18	13	15	6	1	0
	Worker gets hit by formwork	B19	1	10	17	3	4
	Worker slips and fall	B20	2	9	13	9	2
Ready mixed cycloop concrete (concrete 60%, stone 40%) quality, f'c = 20 Mpa (K225)	Danger of falling stones/rocks	B21	2	9	13	10	1
	Danger of hand squeezed by rocks	B22	1	13	17	4	0
	Danger of get hit by concrete debris	B23	2	9	13	9	2
	get hit by falling object/landslide from cliff	B24	1	11	15	4	4
	Skin infection due to concrete chemical	B25	2	11	15	4	3
	Danger of being swept away by the river current	B26	2	9	13	9	2
	The existing old pairing collapse or ruin	B27	0	6	11	11	7

4.2.4. Risk Impact of Mortar Stone Installation Work

Table 7.Recapitulation data of mortar stone installation work assessment result

No	Activity	Danger Potential/Risk	Code	Impact Level				
				1	2	3	4	5
1	N type mortar stone installation work (equal mix of 1 PC:4 PP) using concrete mixer truck	Workers exposed or get hit by stone material	BM1	6	7	8	9	5
		Danger of hand getting squeezed by stones or rocks	BM2	3	7	15	8	2
		Worker gets hit by falling object/landslide from cliff	BM3	6	7	8	9	5
	Thick plastering 1,5 cm, with mortar tPC-PP type S (equal mix of 1 PC:3 PP)	Respiratory problem due to sand or concrete dust	BM4	3	7	15	8	2
		get hit by falling object/landslide from cliff	BM5	6	9	8	9	3
	Joint sealing work with mortar PC-PP type M (equal mix 1 PC:2 PP)	Respiratory problem due to dust at channel lining	BM6	7	7	7	7	7
		get hit by falling object/landslide from cliff	BM7	6	7	8	9	5
	Pair dismantling	Worker slips and fall	BM8	0	9	17	9	0
		Workers exposed or get hit by stone material	BM9	3	7	15	8	2
		Worker gets hurt by tool usage (Stone Cutter)	BM10	1	10	13	9	2

4.2.5. Impact Risk on Miscellaneous Work

Table 8.Recapitulation data of miscellaneous work assessment result

No	Activity	Danger Potential/Risk	Code	Impact Level				
				1	2	3	4	5
1	Dewatering	Danger of falling into water puddles	LL1	2	12	16	4	1
		Electric shock because short circuit in water pump machine	LL2	4	11	11	7	2

		Slipped when lowering the pump hose	LL3	4	21	6	4	0
	Cofferdam making	Danger of being swept away by the river current	LL4	0	21	14	0	0
	Material Transporting	Worker's hand and feet pierced or scratched by stones, iron or other materials	LL5	5	6	12	8	4

**4.3. Risk Evaluation**

Purpose of risk evaluation is facilitating decision-making process based on the analysis result. The risk evaluation process will determine which risk that requires treatment and how to prioritize these risks. It can be done through making categorization or classifying the likelihood and consequences values into AS/NZS 4360:2004 risk matrix. Once the likelihood and consequences values are revealed, these values can be plotted on the risk matrix table to determine the level of risk posed. The risk matrix will be explained in the following table (Table 9).

**Table 9.** Recapitulation of risk matrix for Selang Dam rehabilitation work

Impact (Consequences)					
Probability	(1)	(2)	(3)	(4)	(5)
(Likelihood)	Insignificant	Small	Moderate	High	Very High/Catastrophic
(5) Very often	M	M	H (B6,B13,B20)	E (B7)	E
(4) Often	M	M	H (PS1,B1,B27,BM9)	H (PS4,PS8,T3,B3,BM10)	E
(3) Frequent	L	M (PS2,LL1))	M (PS3,PS6,PS7,T1,T2,T5,T7,B9,B11,B12,B14,B16,B17,B18,B19,B23,B25,BM1,BM2,BM4,BM5,BM7,LL2)	H (PS5,T4,T6,LL5)	H
(2) Rare	L	M	M (B4,B5,B8,B10,B15,B21,B22,B24,B26,BM3,BM6,BM8,LL3)	M (LL4,B2)	M
(1) Very rare	L	L	L	M	M

Description:

E :Extreme risk, intolerable and needs immediate treatment.

H : High risk, undesirable and only accepted when risk reduction cannot be implemented and requires special attention from the management.

M :Moderate risk, accepted with approval and requires clear accountability from the management.

L :low risk, accepted with approval by the management and can be addressed by routine procedures.

Based on risk matrix table, distribution of risk categories in this study can be identified where: (a) one (1) variable is included into very high risk category (risk code B7), (b) sixteen (16) variables are included into high risk category (risk codes of PS4, PS8, T3, B3, BM10, B6, B13, B20, PS1, PS5, T4, T6, B1, B27, BM9, LL5), (c) forty (40) variables are included into moderate category (risk codes of PS3, PS6, PS7, T1, T2, T5, T7, B9, B11, B12, B14, B16, B17, B18, B19, B23, B25, BM1, BM2, BM4, BM5, BM7, LL2, LL4, B2, PS2, B4, B5, B8, B10, B15, B21, B22, B24, B26, BM3, BM6, BM8, LL1, LL3,). As the risk treatment act, these risks will be

handled according to the level of the category. High risks variables are undesirable and can only be accepted if mitigation efforts are not possible, thus requiring special attention from the management. While moderate risk variables are still acceptable with approval but still requires clear responsibility from the management and the last category is low risks variables are acceptable with management approval and usually can be handled through routine procedures.

#### **4.4. Risk Control**

Occupational Safety Risk Control is the next step in applying Job Safety Analysis (JSA) method. This control aims to provide alternative solutions to reduce accident risks for Selang Dam Rehabilitation Project. Control measures in JSA can be tailored to the hazard/danger risk level for each work activity since each work activity in construction project has different potential danger. [16]

Occupational safety risks are classified into four categories: very high risk, high risk, medium risk, and low risk. Each risk category requires a different control strategy according to its severity and potential impact on worker safety and project implementation.

In the Selang Dam Rehabilitation Project, the very high-risk category is found in concrete work, with a risk value of 20 for K225 concrete work. This work poses an intolerable risk and has the potential to cause fatal work accidents. In the Selang Dam Rehabilitation Project, risks in this category are generally associated with working at heights, working on steep slopes, and slips and falls due to activities carried out near rivers.

A high risk is a risk that has a high potential to cause a serious workplace accident if not adequately controlled. A medium risk is acceptable, but still requires control to prevent it from developing into a high risk. A low risk is a relatively small risk that can be accepted with routine controls.

Risk control strategies can be conducted by giving briefings (safety induction) for new workers, tool box meeting at work location before carrying out work activities, SMT (Safety Morning Talk) once a week to provide general briefings for both workers and staff of the project, safety meeting once a week to discuss work problems that occur in the field and get solutions, conducting periodic K3 safety patrols, also providing complete Personal Protective Equipment (PPE) for foreman workers and related partners in the related project. [17]

The following explanation consists of risk control steps to be implemented in the Selang Dam Rehabilitation Project in Pasuruan Regency where is found to be fall into very high-risk category:

##### 1. Technical control

- Construction work will be carried out during low tide and is scheduled to be implemented during dry season (July, August, September and October).
- Constructing a strong temporary cofferdam to hold back water flow and keep the work area dry.
- Lighting and access: since dam areas often slippery and steep, it requires sturdy access ladders, handrails, and adequate lighting in case for overtime work.
- Checking the work equipment before use, to ensure these tools are ready and safe to use. After the workers finished, return the equipment to the designated safe place.

##### 2. Administrative control (procedures)

- Requests work permit from authority agencies.
- SOP implementation.
- Weather Monitoring: employs dedicated watchman to monitor water discharge in upstream area and communicating with the rain monitor officer at the relevant agencies. When heavy rain occurs in upstream area, workers must be evacuated from downstream or dam area in immediate time (for anticipating flash flood that might be happening).
- Toolbox Meeting: daily morning briefing to discuss potential specific danger on that day in the rehabilitation area.
- Performing safety patrols throughout work area to do routine monitoring and notify workers of any potential danger while working.
- Having competent and certified personnel according to their expertise and work positioning.

##### 3. The Personal Protective Equipment (PPE) as last line of defense where every worker obliged to use:

- Helmet, safety gloves & Safety Shoes: a protective wears from impacts and sharp objects.
- Life Jacket: essential for workers who work above or at the edge of deep water.
- Safety Glasses and mask: protect eyes from flying debris of concrete, rock, sand and dust.
- Police Line and safety signs: serve as physical barrier, visual warning, and alerts to potential hazard.
- Safety Rope/Guide Rope: a wire sling that helps worker standing or overcome pressure of water currents when crossing river.
- Rescue rope: rope that must be always available at the edge of waterways in case of emergency.

- Stick or tracking poll: workers can use these poles to check water depth or detect holes or potholes before stepping in to prevent falling.

## V. CONCLUSION

Based on the results of the analysis and discussion regarding occupational safety risk management in the Selang Dam Rehabilitation Project in Pasuruan Regency, several conclusions can be drawn as follows:

1. The risk identification of occupational safety risk in Selang Dam Rehabilitation Project showed for each stage of work (starting from preparatory work with eight (8) variables, earthwork with seven (7) variables, concrete work with twenty-seven (27) variables, mortar stone installation work with ten (10) variables and miscellaneous work with five (5) variables) has a variety of potential hazard/danger. These dangers are mainly influenced by condition from project location which is difficult to reach, steep slopes, risk of falling from high place, use of heavy equipment, as well as environmental condition that influenced by weather and river flow.
2. From the result of risk analysis by employing AS/NZS 4360:2004 method showed that the work safety risk is found at a Very High category where 1 variable including concrete work and variable of worker slipping risk has a value of 20.
3. The occupational safety risk control that implemented in Selang Dam Rehabilitation project in Pasuruan Regency for work classified as having Very High-Risk level is:
  - Aspect of technical control: work execution time, temporary embankment construction, site access, adequate lighting, and equipment checking.
  - Administrative control: requesting work permit, SOPs implementation, weather monitoring by assigning special personnel, holding technical toolbox meeting, conducting safety patrols, and employing competent and certified personnel in work field.
  - Personal Protective Equipment (PPE) including installation of safety signs, crossing ropes, life jackets, walking sticks or trekking poles, and the obligation and use of Personal Protective Equipment (PPE) adjusted to the type of work and its risk level.

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