

# Work Accident Risk Analysis on the RDMP Building work Package 1 Project Using Bowtie Method

C S F Zhahra<sup>1,2</sup>, A J Pratama<sup>1,3</sup>

<sup>1</sup>Industrial Engineering Departement, Faculty of Science and Technology, Al Azhar University Indonesia, Al Azhar Grand Mosque Complex, Sisingamangaraja Street, Jakarta, 12110

<sup>2</sup>fatimahcutshity@gmail.com, <sup>3</sup>juang@uai.ac.id

**Abstract.** Construction work has a high potential risk of work accident because the work is difficult, involves many parties and is directly related to hazards in the workplace. In addition, it is necessary to pay attention to the guarantee of occupational safety and health for workers, it is necessary to carry out occupational safety and health risk management. The research was conducted on the RDMP Building Work Package 1 project with the aim of analyzing and preventing work accidents. The research steps are hazard identification, risk assessment, risk analysis using the Bowtie method, designing risk control using the hierarchy of control. Based on research that has been carried out, the identified hazards and risks are extreme, namely exposure to hazardous and toxic materials, electric shock, being crushed, slipping, falling from a height, injured, pinched by tools, heavy equipment falling, hitting workers and materials, scratched, crushed, tripped, sling crane broke. The risk of extreme accidents with the highest risk value of 16 with Bowtie analysis is the danger of rainy weather with the peak event of a slippery work area caused by an uneven ground surface, standing water, and not tidying work area. The impact is work delays, workers slip and fall.

**Keywords:** bowtie analysis method, risk assessment, risk control, risk identification, risk management

## 7. Introduction

Risk is a condition of uncertainty in which there is an aspect that can cause loss or accident. This risk is found in all aspects of life, especially in the world of work. In addition to the need to avoid work accidents and losses, there are other aspects that must be considered, namely guarantees for the health and safety of workers in the workplace. This is regulated in Law no. 13 of 2003 Article 86 which reads "Every worker/labor has the right to obtain protection for occupational safety and health"[1]. Construction work can be said to be one of the jobs that has a high possible risk of work accidents, this possibility can be caused by a lack of awareness of workers about occupational safety and health culture, complicated work, work that involves many parties and is directly related to sources of danger in the workplace. Occupational safety and health management is a system that regulates and protects workers or work providers such as construction services from losses, lost working hours, and work accidents and can improve effective and efficient performance.[2]. The problem being investigated is the potential risk

of work accidents that can cause losses. This research was conducted to identify the hazards and risks of work accidents and to provide suggestions for preventing and dealing with them if risks occur so as to prevent severe or detrimental impacts for workers and companies.

The Pertamina Balikpapan RDMP project is a refinery development project with the aim of increasing the capacity and quality of refinery production. One of the projects to support the sustainability and success of the objectives of the Pertamina Balikpapan RDMP project is to build supporting facilities. The construction of these supporting facilities was carried out in the RDMP Building Work Package 1 project, namely civil works for the construction of the control room building as a supporting facility for the development of the refinery. This control room will later function as a control room, monitor and control the production activities of the Pertamina Balikpapan refinery. The RDMP Building Work Package 1 project has the potential for hazards that can cause work accidents. Potential hazards that can occur in such work include the use of heavy equipment, sharp objects and materials, working at heights or confined spaces, unfit worker conditions and other possible hazards. In addition, this project is carried out in a refinery area which has the potential for explosions and fires. In 2022 alone, Pertamina Balikpapan Refinery recorded 2 fire incidents, namely on March 4, 2022 and May 15, 2022. In addition to this, the possibility of danger in this work can occur because the work is difficult, involving many parties with great job risks.

So to minimize this from happening, it is necessary to carry out risk management on the RDMP Building Work Package 1 Project. Risk management begins with identifying potential hazards and risks or consequences arising from hazards. After the hazards and risks are identified, a risk assessment is carried out based on the severity and probability of the occurrence of risks with risk categories obtained with a risk matrix. Then a risk analysis is carried out to determine the causal factors and the resulting effects in order to control the causes and effects that occur with the Bowtie method. The Bowtie method is a risk management method created by drawing a diagram in the form of a bow tie. The Bowtie method is a combination of two methods, namely FTA (Fault Tree Analysis) and ETA (Event Tree Analysis)[3]. *The next stage is risk control with a hierarchy of control with stages, namely elimination, substitution, engineering control, administrative control and the use of PPE when working*[4].

## 8. Methods

This research was conducted to analyze and design extreme work accident risk control measures in the RDMP Building Work Package 1 project. This research was conducted at PT. XYZ is a company engaged in engineering and construction. Data collection was carried out by observation, interviews, distribution of questionnaires and supporting data for work method statements which provide information on activities carried out on the project, materials and tools used in the project. Interviews and distributing questionnaires were carried out with 3 experts.

### *Hazard Identification*

Hazard identification was carried out on 8 jobs in the RDMP Building Work Package 1. Factors causing work accidents or hazards were identified based on risk aspects according to Ishikawa, namely 4M+1E, namely man, machine, material, method and environment. Data was collected through observation, interviews and supporting data for work method statements that provided information on the activities carried out on the project, materials and tools used in the project.

### *Risk Assessment*

Risk assessment data was collected through distributing questioners or interviews base on expert opinion. Interviews and questionnaires were distributed by 3 experts with the following criteria, expert 1 with the position of HSE (safetyman) with 3 years of work experience and has K3 Oil and Gas certification, expert 2 with a supervisory position with 5 years of work experience and has an authorized gas detector certification, expert 3 with the position of site manager with 15 years of work experience and has an authorized gas detector certification. Work accident risk assessment is carried out based on the guidelines of the Australian Standard/New Zealand Standard for Risk Management (AS/NZS

4360:2004) with 2 risk parameters, namely probability and severity. Probability is the level of possibility of a work accident risk. While severity is the severity of the risk of work accidents that occur [5].

**Table 1.** Probability.

Scale	Description	Information
1	Rare	An incident that may occur only under certain conditions special/amazing/after many years (There is < 1 event in a year)
2	Unlikely	An incident that may occur under certain conditions, but the chance of occurrence is small (rare) (There is ≥ 1 event in a year)
3	Possible	An incident that will occur under certain conditions (There is ≥ 1 event in a month)
4	Likely	An incident that is very likely to occur (periodically) in almost all conditions (There is ≥ 1 event in a week)
5	Almost Certain	An incident that is bound to happen in all conditions (There is ≥ 1 event in a day)

**Table 2.** Severity.

Scale	Description	Information
1	Insignificant	No Injury – low value for money loss
2	Minor	Minor Injury – medium financial loss need first aid treatment on the spot
3	Moderate	Moderate Injury – financial loss is quite high On-site medical treatment is required due to loss of function limbs for a while
4	Major	Serious Injury – high financial loss medical treatment is required due to a physical disability total so that it interferes with the production process
5	Catastrophic	Fatal Events – very high financial losses There have been cases of death, poisoning with disruptive effects large and have an impact on the cessation of all activity

After getting the probability and severity scale, then calculate the probability index and severity index. The value of the probability index and severity index is calculated based on the probability and severity scale obtained from expert answers with the formula in the equation[3](1):

$$PI/SI(\%) = \frac{\sum_{i=1}^5 a_i n_i}{5N} \times 100\% \quad (1)$$

Information:

PI/SI= Probability Index and Severity Index

ai= Probability Scale and Severity(1,2,3,4,5)

ni= Number of Experts Answering

N= Total Number of Experts

The calculation results of the probability index and severity index that have been processed based on are then converted according to the percentage of numbers obtained to obtain the identified occupational accident risk categories.

**Table 3.** Parameters of the Index Scale Obtained[5].

Scale	Index
1	0% < I ≤ 20%
2	20% < I ≤ 40%

3	40% < I ≤ 60%
4	60% < I ≤ 80%
5	80% < I ≤ 100%

The risk assessment is based on the scale that has been obtained as follows[4]:

$$R = P \times S \quad (2)$$

Information:

R= Risk Value

P= Probability

S= Severity

The next step after grouping the probability and severity index based on the index acquisition is to categorize the risk with a risk matrix.

**Table 4.** Risk Matrix[6]

		Severity				
		Insignificant	Minor	Moderate	Major	Catastrophic
Probability		1	2	3	4	5
Almost Certain	5	High	High	Extreme	Extreme	Extreme
Likely	4	Moderate	High	High	Extreme	Extreme
possible	3	Low	Moderate	High	Extreme	Extreme
Unlikely	2	Low	Low	Moderate	High	Extreme
Rare	1	Low	Low	Moderate	High	High

#### Bowtie Analysis

The Bowtie diagram that is created illustrates the relationship between cause and risk and risk and consequence. The results of the analysis using the Bowtie method are preventive measures, mitigation that can be done, recovery, escalation factors and escalation control. Steps of risk analysis with Bowtie method[7]:

- 1). Hazard identification
- 2). Determine the top event, the top event at the center of the Bowtie diagram is between threat and consequence.
- 3). Determine the threat or cause of the top event, its placement is on the left on the Bowtie diagram.
- 4). Determine the consequences, the consequences are the impact of the top event and on the Bowtie diagram the consequences are placed to the right of the top event.
- 5). Identification of prevention control (precautionary action), placed on the left side of the diagram is between the top events and threats.
- 6). Determine recovery (mitigation control), carried out to reduce the consequences or impacts caused by the top event, which is placed to the right or between the top event and the consequence.
- 7). Determine escalation factors and escalation controls.

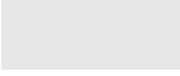
The Bowtie diagram consists of several symbols to distinguish the intent and meaning of each activity or risk. The symbols used in the Bowtie diagram presented in table 5.

**Table 5.** Bowtie Diagram Symbols

No	Symbol	Information
1		Hazard: a cause for the occurrence of risk.

- 2  Top Events: events resulting from loss of control over the hazard.
- 3  Threats: the reason for the loss of control over the hazard leading to the top event.

**Table 5.** Bowtie Diagram Symbols

No	Symbol	Information
4		Consequences: unexpected/desirable impacts due to top events and hazards.
5		1). Preventive barriers: controls to prevent threats from occurring. 2). Mitigative barriers: controls to control and prevent consequences. 3). Escalation control: controls to prevent the occurrence of escalating factors (failure of control)
6		Escalation factors: the reason for the failure of a control (preventive and mitigative barriers) that was implemented.

#### *Determining/Risk Control*

Hierarchy of control is a design to control a risk that occurs in the form of control in the form of levels and carried out in stages. The following are the stages of risk control[4]:

- 1). Elimination: the process of controlling risk by eliminating the source of danger in the form of tools, processes, machines or materials with the aim of protecting workers.
- 2). Substitution: is done by changing materials, processes, machines or materials from those that have the potential to cause harm to become safer to use or harmless.
- 3). Engineering: is done by designing or modifying a tool to make it safer to use.
- 4). Administrative control: carried out by making SOPs, making rules, work shifts, work duration, signs at work sites, danger signs.
- 5). Personal protective equipment: the use of personal protective equipment is the last stage in risk control. This is done by always using PPE when working such as coveralls, safety helmets, goggles, masks, safety shoes, gloves, ear plugs, body harnesses[4].

The limitation of this research is only identifying hazards and providing suggestions for preventing or avoiding the occurrence of hazards, not conducting research on the effectiveness of the proposed controls.

#### 9. Result and Discussion

The identification of hazards and risks of work accidents in the RDMP Building Work Package 1 project was carried out on 8 jobs and with risk factors, namely man, machine, material, method and environment. There are 53 potential risks of work accidents identified based on the observation and interview process.

**Table 6.** Hazard & Risk Identification and Risk Assessment

No	Activity	Hazard	Risk	Code	P	S	Risk Value	Risk Category
1	Mobilization of workers,	Man: Workers' health conditions are not prime	Fall	1A	4	3	12	High

tools and materials	Machine: Incomplete tool document	Work Late	1B	3	2	6	Moderate
	Material: Excessive use of Hazardous and Toxic Substances	Exposure to Hazardous and Toxic Substances, poisoning, pollution, explosion, fire, death.	1C	3	5	15	Extreme

**Table 6.** Hazard & Risk Identification and Risk Assessment

No	Activity	Hazard	Risk	Code	P	S	Risk Value	Risk Category
		Method: Overload during mobilization	Occupational illness (fatigue, back pain, musculoskeletal disorder)	1D	4	2	8	High
2	Excavation	Man: Workers are less concentrated	Wounded	2A	5	2	10	High
		Machine: Use of sharp tools (hoe, crowbar) or heavy equipment (excavator) that is not suitable, damaged tools	Workers injured or scratched by a hoe	2B	4	3	12	High
		Machine: Use of sharp tools (hoe, crowbar) or heavy equipment (excavator) that is not suitable, damaged tools	Heavy equipment crashes, sinks	2C	3	3	9	High
		Material: Excavated land that is scattered and flying,	Soil is inhaled and enters the eye	2D	5	1	5	High
		Electrical hazards or underground cables/pipes	Electrocution, death	2E	3	4	12	Extreme
		Method: Wrong work order or excavation technique error	Longer duration of work completion	2F	4	2	8	High
		Environment: Excavation pits and excavation remnants that are not immediately cleaned up, landslide excavations.	Workers stumbled or buried into dug holes, tripped, fell	2G	3	3	9	High

		Environment: Working in a confined space, poor air circulation, poorly lit and cramped workplace	Shortness of breath and fainting	2H	3	2	6	Moderate
			Slip, trip, fall	2I	4	3	12	High
3	Scaffolding Installation and Dismantling	Man: Inexperienced worker working at height, Disinterested worker	object fall	3A	4	2	8	High
		Machine: Scaffolding collapsed	Stuck, pinched, death	3B	3	4	12	Extreme
		Material: Sharp surface of scaffolding parts	Injured, injured	3C	3	4	12	Extreme

**Table 6.** Hazard & Risk Identification and Risk Assessment

No	Activity	Hazard	Risk	Code	P	S	Risk Value	Risk Category
		Method: Error in the method of mobilizing tools and installing scaffolding, Working at heights	Objects fall and hit workers	3D	3	3	9	High
		Environment: Rainy weather conditions make the work site slippery	Slip and fall from a height, death	3E	4	4	16	Extreme
4	Welding, Cutting, Grinding	Man: Conditions of exhausted workers	Injured, pinched tool	4A	3	4	12	Extreme
		Machines: The condition of the tool is damaged (Cable chipped)	Electrocution, death	4B	3	4	12	Extreme
		Material: Smoke from the cutting and grinding welding process	Inhalation, eye irritation and shortness of breath	4C	3	3	9	High
		Material: Sparks	Body hit, burns	4D	3	3	9	High
		Material: UV rays	Impaired vision, eye irritation	4E	3	3	9	High
		Methods: Improper installation of grinding stones and electrodes	Cut, Hurt	4F	3	3	9	High
		Environment: scrap messy cutting marks	Punctured, scratched, injured	4G	4	3	12	High
		Environments: Noise	Hearing disorders	4H	4	2	8	High
5	Erection	Man: Workers do not follow work instructions	Postponement of work activities	5A	3	2	6	Moderate

	Machines: Heavy equipment fell/slipped	Affect workers (wounded, pinched, injured), damage to infrastructure, death	5B	3	4	12	Extreme	
	Material: Poor material quality	Hurt workers	5C	2	4	8	High	
	Methods: Wrong piling method	The stake fell on the worker	5D	2	4	8	High	
	Environments: Uneven ground	Tool/worker fell	5E	3	3	9	High	
6	Reinforcing	Man: Workers with less experience in iron work	Work accident, long working duration	6A	4	2	8	High

**Table 6.** Hazard & Risk Identification and Risk Assessment

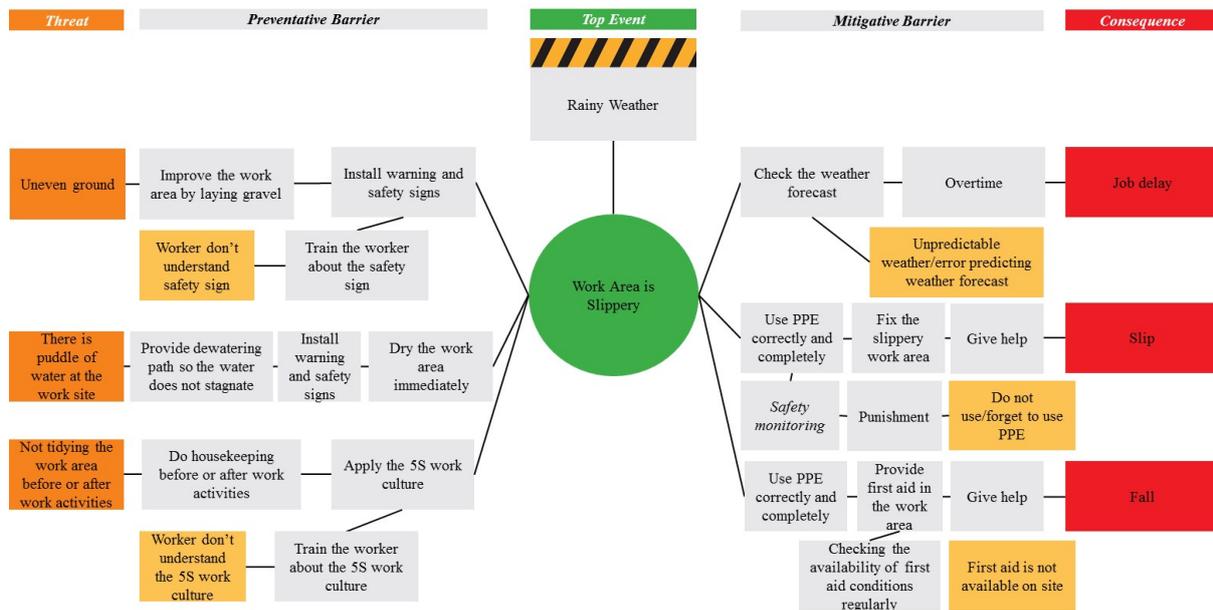
No	Activity	Hazard	Risk	Code	P	S	Risk Value	Risk Category
		Machine: Use of sharp tools (saws, grinders)	Cut, scratched, injured	6B	4	4	16	Extreme
		Material: Use of sharp surface materials (iron, wire)	Punctured, scratched	6C	3	3	9	High
		Method: Iron method error	The building structure is not strong	6D	3	3	9	High
		Environment: Work area littered with iron tools and materials	Stumbled, fell	6E	5	3	15	Extreme
		Environment: Hot weather	Exposure to direct sunlight (sunburn, skin cancer)	6F	3	2	6	Moderate
			Dizziness, fainting	6G	3	2	6	Moderate
7	Formwork	Man: Workers are not interested in the work area	Material hit	7A	3	2	6	Moderate
		Machine: The use of crane car is broken (Sling crane broke)	Overwrite workers	7B	2	5	10	Extreme
		Material: Use of iron/wire and wood dust	Scratched limbs, injured	7C	3	3	9	High
			Eye irritation	7D	3	2	6	Moderate
		Method: There was a communication error during the work process	Delay in work process	7E	3	1	3	Low

		Environment: Uneven ground	Crane car sinks	7F	3	3	9	High
		Environment: Working at height	Falling/falling objects	7G	3	4	12	Extreme
8	Casting	Man: Uninterested workers in the foundry area	Inhibiting other work	8A	3	1	3	Low
		Machine: Use of generator (electricity)	Got electric shock	8B	2	3	6	Moderate
			Fire due to electric short circuit	8C	3	3	9	High
		Use of heavy equipment (dumb trucks, mixer trucks)	Heavy equipment fell or hit workers/materials	8D	2	4	8	High
		Material: Chemicals in cast cement dough, Flying material (concrete dust)	Exposure to concrete splashes (skin irritation)	8E	3	3	9	High

**Table 6.** Hazard & Risk Identification and Risk Assessment

No	Activity	Hazard	Risk	Code	P	S	Risk Value	Risk Category
		Method: Casting method error, Lack of supervision from QC	Postponement of work, demolition of castings	8F	3	2	6	Moderate
		Environment: Slippery work area due to foundry work.	Slipped, fell	8G	3	3	9	High

The results of the risk assessment in table 6 show 12 occupational accident risks in the extreme category, 30 work accident risks in the high category, 9 work accident risks in the moderate category and 2 work accident risks in the low category. Based on table 6, there are 2 risks of work accidents with the extreme category and the highest risk value is 16, namely the risk of 3E and 6B. 6E risk is slip and fall from a height, death. Risk 6B is cut, scratched, injured as a result of using sharp tools. These two work accident risks are followed by an analysis process using the Bowtie method and risk control using a hierarchy of control.



**Figure 1.** Risk Analysis using the Bowtie Method on the Risk of Accidents at Work 3E

Figure 1 presents an analysis of the risk of a 3E work accident that has the potential to injure workers because the work area is slippery due to rainy weather, along with an explanation of the Bowtie diagram.

**Hazard:** Rainy weather

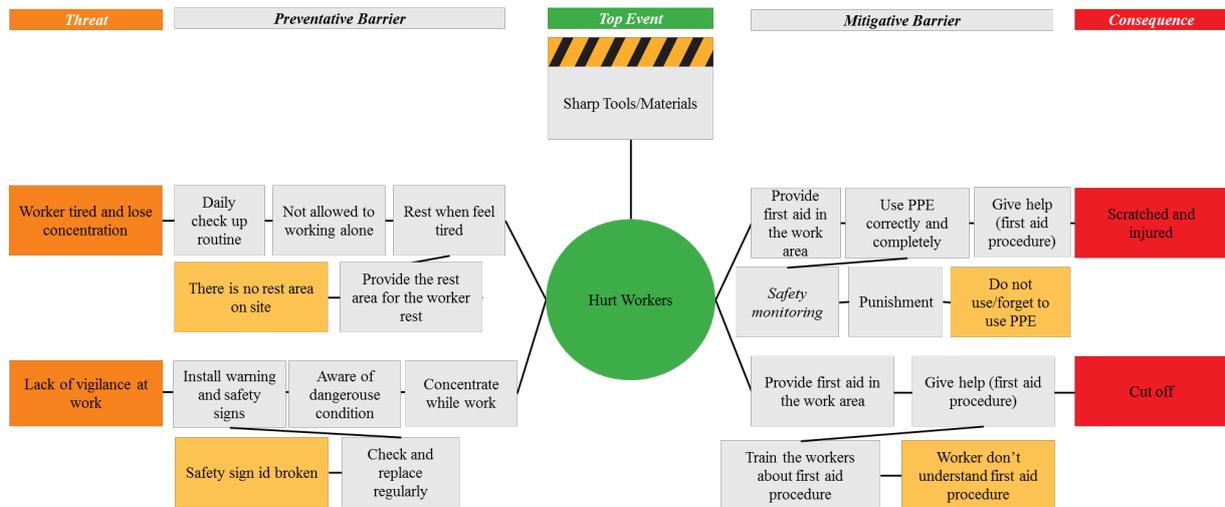
**Top Event:** Slippery work area

1. The causes of the slippery work area, namely:
  - a. Uneven ground
  - b. There is a puddle of water in the work area
  - c. Not tidying up the work area after work
2. The impact of the slippery work area incident, namely:
  - a. Job delay
  - b. Slip
  - c. Fall

Controls for possible causes and impacts are shown in Figure 1. Controls are carried out to deal with real events in the field. If it happens at any time, it can face the causes and impacts that arise so that the risk of work accidents is not too severe. This control and control also has the potential to fail, this event is called an escalation factor and control is carried out with escalation control.

The design of the control hierarchy of control for the risk of work accidents 3E, namely:

1. Engineering: provide dewatering path for water flow.
2. Administrative controls: make it a habit to do housekeeping before and after work, dry wet work areas, be aware of hazardous conditions in the workplace, conduct work site surveys, provide first aid at work.
3. Personal protective equipment: coveralls, safety shoes, helmets, gloves, safety glasses, masks, body harnesses.



**Figure 2.** Risk Analysis with Bowtie Method on Work Accident Risk 6B

Figure 2 is 6B work accident risk analysis, where workers are injured as a result of the use of sharp tools or materials, is presented with the Bowtie diagram attached in Figure 2 with the following explanation:

**Hazard:** Sharp tools/materials

**Top Event:** Hurt workers

1. The causes of the events that occurred, namely:
  - a. Workers are tired and lose concentration
  - b. Use of tools/materials with sharp conditions
2. The impact of the incident, namely:
  - a. Scratched and injured
  - b. Cut off

The preventive control of the causes and the recovery control of the impact are presented in Figure 2. The failure factor in the prevention and recovery control is called the escalation factor and the control of the escalating factor is called the escalation control. The control design is made to manage scenarios if the incident actually occurs and can minimize the impact of the risk of work accidents.

The design of the control hierarchy of control for the risk of work accidents 6B, namely:

1. Engineering: Install safety (blade cover, circular saw holder) on sharp tools.
2. Administrative control: make sure before use the tool has gone through the inspection process, install safety signs at the work site, concentrate while working, provide first aid at work.
3. Personal protective equipment: coveralls, safety shoes, helmets, gloves, safety glasses, masks.

The controls carried out for each threat and the consequences that can occur are divided into 2, namely prevention and mitigation contained in the bowtie diagram presented in Figures 1 and 2. Preventive controls are carried out to prevent the threat of work accidents, while mitigation controls are carried out to deal with the consequences of events.

## 10. Conclusion

Based on the data collection, processing and analysis that has been done, it can be concluded that.

- 1 Potential hazards that can occur in the RDMP Building Work Package 1 project, including: worker health conditions (physical and mental), worker competence, human error, damaged equipment conditions, incomplete/out-of-date equipment documents, use of tools sharp tools, improper use of heavy equipment, use of electric tools, poor material quality, excessive use of hazardous and toxic materials, sharp material surfaces, cutting scraps, material falls, wrong load lifting methods, wrong or reverse working methods (not according to instructions), communication method (misperception),

lack of supervision at work, messy work area, uneven ground surface, erratic weather, noise, working in confined spaces and working at heights.

- 2 The potential risks of work accidents that can occur in the RDMP Building Work Package 1 project, namely: exposure to hazardous and toxic materials, electric shock, crushed and pinched by scaffolding, injured and injured, slipped and fell from a height, injured and pinched by tools, electrocuted, workers crushed and damaged infrastructure due to heavy equipment falling/slipping, cut, scratched and injured, tripped and fell, workers hit by broken sling cranes, falls and objects fall.
- 3 Risk analysis on the risk of a 3E work accident with the hazard of rainy weather and slippery work area top event. Due to uneven ground surface, there is standing water in the work area and not doing housekeeping after work. This incident can cause the impact of work delays, slip and fall.
- 4 Hierarchy of control risk control against 3E risk of slipping and falling from a height, control is carried out by providing dewatering paths, make it a habit to do housekeeping before and after work, dry wet work areas, instill an attitude of awareness of dangerous conditions at work, perform site surveys provide first aid at work sites and use of complete PPE at work and in the work area.

### Acknowledgments

Authors would like to thank Al Azhar University Indonesia, Industrial Engineering Study Program, supervisors and related companies who have provided invaluable opportunities, experiences and learning during this research period.

### 11. References

- [1] KEMENPERIN, “Undang - Undang RI No 13 tahun 2003,” *Ketenagakerjaan*, no. 1, 2003.
- [2] S. Waruwu and F. Yuamita, “Analisis Faktor Kesehatan Dan Keselamatan Kerja (K3) Yang Signifikan Mempengaruhi Kecelakaan Kerja Pada Proyek Pembangunan Apartement Student Castle,” *Spektrum Ind.*, vol. 14, no. 1, p. 63, 2016, doi: 10.12928/si.v14i1.3705.
- [3] I. A. Alfarezi, J. W. Soetjipto, and S. Arifin, “Analisis Risiko Keselamatan Dan Kesehatan Kerja (K3) Pada Masa Pandemi Covid-19 Dengan Metode Bowtie Analysis,” *J. Tek. Sipil*, vol. 10, no. 2, pp. 96–105, 2021, doi: 10.24815/jts.v10i2.21923.
- [4] T. Saputro and D. Lombardo, “Metode Hazard Identification, Risk Assessment And Determining Control (HIRADC) Dalam Mengendalikan Risiko Di PT. Zae Elang Perkasa,” *J. Baut dan Manufaktur*, vol. 03, no. 1, pp. 23–29, 2021, [Online]. Available: <https://uia.e-journal.id/bautdanmanufaktur/article/download/1316/761/>.
- [5] W. B. Veroza and C. B. Nurcahyo, “Analisis Risiko Kecelakaan Kerja Pada Proyek Spazio Tower II Surabaya Menggunakan Metode Bowtie,” *J. Tek. ITS*, vol. 6, no. 2, pp. 204–210, 2017, doi: 10.12962/j23373539.v6i2.25473.
- [6] A. Maddeppungeng, S. Asyiah, and M. Iqbal, “Metode Bowtie Untuk Dampak Kecelakaan Kerja Pada Proyek Jalan (Studi Kasus Proyek Pembangunan Jalan Tol Serpong – Balaraja Seksi I a),” *Konstruksia*, vol. 12, no. 1, p. 135, 2021, doi: 10.24853/jk.12.1.135-143.
- [7] J. Aust and D. Pons, “A systematic methodology for developing bowtie in risk assessment: Application to borescope inspection,” *Aerospace*, vol. 7, no. 7, pp. 1–37, 2020, doi: 10.3390/AEROSPACE7070086.