#### PAPER • OPEN ACCESS

# Risk assessment for occupational health and safety of Soekarno-Hatta international airport accessibility project through HIRARC method

To cite this article: S Fauziyah et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 700 012048

View the article online for updates and enhancements.



This content was downloaded from IP address 114.5.246.32 on 31/03/2021 at 02:19

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

### Risk assessment for occupational health and safety of Soekarno-Hatta international airport accessibility project through HIRARC method

S Fauziyah<sup>1</sup>, R Susanti<sup>1</sup>, and F Nurjihad<sup>2</sup>

<sup>1</sup>Diponegoro University <sup>3</sup>Mercu Buana University

shifa.fauziyah@live.undip.ac.id

Abstract. Statistic based on BPJS data in 2019 have shown that the number of work accident recorded 77.295 cases and the construction sector is still the highest contributor to work accident cases in comparison to other sectors. Soekarno-Hatta International Airport accessibility project connects the northern perimeter road with the southern perimeter road with a total length of 4 km. This study focuses on the flyover construction, considering that is the highest risk on construction activities. Risk assessment tool on this research using HIRARC method. In general, there are three major steps of HIRARC; hazard identification, risk assessment and risk control. Identifying hazard is a process to determine the risks of hazards that occure in construction work. Assessing risk of construction work calculated using likelihood and severity index. Then, the result of hazard identification and risk assessment, risk control are taken to mitigate the hazard risk. This study instrument used interviews and observations both used risk assessment sheet which filled by safety officers, safety supervisors, site engineers and site supervisors. There were 45 hazards identified for five construction work which are, (i) survey (ii) land clearing, (iii) excavation work, (iv) pilling work, and (v) bored pile work. The conclusion that can be drawn is that there are seven extreme risk at this project, i.e. (i) Workers fall into lake; (ii) Workers get hit by road users; (iii) The operator is exhausted; (iv) Crane wire rope failure; (v) Vibro hummer failure; (vi) Workers pinched by bracket formwork and (vii)Workers injured by pieces concrete pile cutting.

#### 1. Introduction

Soekarno-Hatta International Airport Accessibility project is built above Soekarno-Hatta Airport lake. The flyover will directly connect two roads North Perimeter Road and South Perimeter Road. The total length of the flyover is 4 km and used pile foundation. The flyover started its construction in March 2019 with total duration of 510 workdays. The construction of flyover, shaped like a half-leaf clover, aims to increase accessibility to the airport.

Soekarno-Hatta International Airport Accessibility project is mega project with rigid regulation about safety, health and environmental (SHE). Although, accidents could occur unpredictable and cause minor injuries, major injuries, worst death and costly enormous losses [1]. The accident rate is depend on the involvement of many workers, large plants, various materials, complex construction method, and complex management tasks [2]. Construction of Soekarno-Hatta International Airport

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI. Published under licence by IOP Publishing Ltd 1

Accessibility project included various construction works that are hazardous such as piling above the lake using heavy equipment. The location of contruction also near uses public road.

This research goals to identify the potential hazard and risk to occupational safety and health and find the most effective way to control the hazard risk. There were five activities identified at Soekarno-Hatta International Airport Accessibility project which are (i) survey, (ii) land clearing, (iii) excavation work, (iv) pilling work, and (v) bored pile work. The objectives of this study are to identify hazards during construction works, to assess the risk level of those hazards and to determine the risk control action. The result of this research for the company in order to reduce hazard risk during construction work. The research method has taken quantitative approach applying a risk assessment datasheet as the instrument tool.

#### 2. Literature Review

#### 2.1 Risk Management

Risk management is an systematic effort to minimize the impact of uncertain condition and/or to reduce the probability of the negative events. Construction sector is close with hazardous and accident. There are five domino factors causing to a construction accident i.e (i) Man, (ii) Machine, (iii) Material, (iv) Method, and (v) Environment as known as 4M+1E [3]. Accidents cause injuries even death [4]. Accidents occurred when worker performed unsafe acts or there were direct physical hazards related to the construction work [3].

The mitigation of construction accidents usually requires predicting future accidents. Risk management is an approach effort to - mitigate accidents by early hazard identification and recommending corect control action [5]. Risk management based on the process of identifying potential hazard, analyzing and evaluate the risk hazard and taking prevention steps to minimize or reduce the risk.

#### 2.2 Hazard Identification, Risk Assessment and Risk Control (HIRARC)

Hazard Identification, Risk Assessment and Risk Control (HIRARC) have become an important method in practice of risk management and assessment. HIRARC was used to identify list of hazards was advanced and analyzed therefore to recommend necessary corrective action [6]. According to, HIRARC is a method that starts from establishing the types of work activities then identified his source of hazard until find the risk value. This method, makes it easier to explore the hazards at each step of the construction work.

#### 2.2.1 Hazard Identification.

Hazard is a potential condition to cause harm to man, machine, material, method, and environment [7]. The early step in risk management starts with identifying hazards. Hazard identification is the process of exploring each work location for the main goal of identifying all the hazards which are essential in the job. Hazards are occur in every workplace [8]. Hazards are categorized into six types: physical hazard, chemical hazard, biological hazard, ergonomic hazard, mechanical hazard, electrical hazard, and psychological hazard stress [9]. In the process of recognizing hazards in construction project, hazard that often occured are (i) construction site itself i.e. area condition and accessibility, (ii) the construction design, (iii) height or depth project characteristics, (iv) hazardous material items i.e. handling, using, storing and delivering, (v) construction method (vi) plant and equipment i.e. installation, erection, commissioning, use, repair, maintenance, transport, storage and disposal, (vii) handling procedure and (viii) environment i.e. materials falling, electric shock, fire or explosion, vibration, noise, heat, cold, stuck, slips, trips, falls, confined space and polluted environment [7]. Hazard identification can be applied as an improvement ways for investigations, supervisions, training, and pre-work designing by supervisors.

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

#### 2.2.2 Risk Assessment

Risk assessment is the whole process of risk analysis [7]. Risk measurement aims to evaluate the hazard. Calculating the risk value of construction hazards depends on the likelihood (L) and severity (S). Risk value is determined by multiplying the hazard likelihood with the hazard severity with the formula

Risk (R) = Likelihood (L)  $\times$  Severity (S)

(1)

**IOP** Publishing

Risk assessment matrix is the combination of likelihood (L) and consequence or severity (S) range that presents an estimate of risk level. Based on PT.X's procedure [10], the risk assessment matrix was categorized into four levels: extreme risk, high risk, moderate risk, and low risk. This risk level is adopted from the applicable risk matrix. PT. X used HIRARC process guideline for this (as shown in table 1 and 2).

Table 1. Risk assessment matrix								
	SEVERITY					RISK LEVEL		
LIKELIHUUD	1	2	3	4	5	(S X L)		
А	Η	Η	E	E	Е	E = Extreme Risk		
В	Μ	Н	Η	E	Е	H = High Risk		
С	L	М	Н	Е	Е	M = Moderate Risk		
D	L	L	Μ	Η	Е	L = Low Risk		
Е	L	L	М	H	Н			

**Table 2.** Scale for likelihood and severity of hazards

LIKELIHOOD (L)	SEVERITY (S)
A = almost certain	1 = First Aid, minor material loss
$\mathbf{B} = \mathbf{likely}$	2 = Medical Treatment Case, medium material loss
C = occasional	3 = Restricted Work Duty Injury, significant material loss
D = unlikely	4 = Lost time injury, major material loss
E = rare	5 = Fatality, very major material loss
(Source: PT. X's proce	edure)

#### 2.2.3 Risk Control

After the hazard identification and risk assessment being applied at the early step, the risk control can be proposed to ensure the safety of construction worker and work site. Risk control is actions taken to mitigate, minimize or eliminate the risk of work site accidents that the hazard does not pose a risk to workers who have to enter into a location or work on equipment/tool of the scheduled task. Risk control is one of the most essential steps to be applied, because at this steps the company must be able to select carefully what type of risk control is the most effective according to the risk level [11]. There are five levels of hazard controls through elimination, substitution, engineering control, administrative control and personal protective equipment.

#### 3. Research Methodology

Data collection in this study can be categorized into two classifications: primary and secondary data. Primary data covers those collected from on-site observation. In-depth interviews using hazard identification checklists with the safety officer of PT. X, the main contractor of Soekarno-Hatta International Airport Accessibility Project. In addition to interviews and observations both used risk assessment sheet. The risk assessment sheet includes hazard identification, risk assessment and risk

control as according to HIRARC process. In-depth interviews with expert are also used to support the results of recent literature studies so that is valid.

Primary data is used to hazard identification, then the risk assessment is carried out, the final step being determining how to control risk. The data collected will be analyzed descriptively, then the results will be given in tables, narration descriptions, and chart.

#### 4. Result and Discussion

The first step in risk management begins with hazard identification and risk assessment. Hazard identification is a systematic process to identify the potential hazards and cause harm to material, tool, or system. There were 45 hazards identified for five activities which are, (i) survey (ii) land clearing, (iii) excavation work, (iv) pilling work, and (v) bored pile work. Hazard identification carried out by PT. X stated in the quality plan and construction method. After all hazard risks have been identified, each hazard risk is calculated to determine the level of risk that caused the accident or loss. The risk assessment conducted by PT.X is adjusted to the established company procedures, namely by determining the likelihood and severity. Table 3 shows hazard identification and risk assessment construction at Soekarno-Hatta International Airport Accessibility Project.

No		Activity	Hazard Identification	Risk Asse	Risk	
			Hazaru luentintation	Likelihood	Severity	Level
1.	Su	rvey				
	a.	Soil Investigation	Workers fall into lake	С	5	Е
			Workers get hit by road users	С	5	Е
	b.	Heavy equipment mobilization	The operator is exhausted	D	5	Е
2.	La	nd Clearing				
	a.	Operating Heavy Equipment	The operator is exhausted	В	2	L
			Hoist hydraulic is detached	С	3	Μ
			Materials fell from excavator	С	3	Μ
			Excavator stuck	D	3	М
3.	Exe	cavation work				
	a.	Soil excavation	The operator is exhausted	С	3	Μ
			Excavator stuck	В	4	Н
			Workers injured from falling objects	В	4	Н
			Tight & narrow access excavation	С	3	Μ
	b.	Soil transportation	The operator is exhausted	С	3	Μ
		-	Workers injured from falling objects	В	4	Н
			Excavators crashing into dump trucks	В	4	Н
	c.	Soil compaction	Workers pinched by compactor	С	3	Н
	d.	Asphalts paving work	Worker injured due to hot asphalt falling	В	4	Н
			Traffic jam	С	4	М
			Roller crashing into dump trucks	В	4	Н
4.	Pil	ling Work				
	a.	Tower crane and diesel hummer operating	The operator is exhausted	D	3	М
			Crane wire rope failure	С	5	Е

 Table 3. Hazard Identification And Risk Assessment at Soekarno-Hatta International Airport

 Accessibility Project

The 9th Engineering International Conference

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

No	o Activity		Hazard Identification	Risk Asso	Risk	
			Vibro hummer failure	D	5	E
	b.	Concrete pile pilling	The operator is exhausted	С	2	Μ
			Trailer truck stuck	D	4	Н
			Ground vibration and noise	С	3	Μ
	c.	Pile connection	Injured by fire when welding	В	4	Μ
	d.	Bracket formwork	Workers pinched by bracket	В	5	E
		installation	formwork			
			Workers fall into lake	С	4	Н
			Crane collaps into lake	С	4	Н
	e.	Pile Cutting	Workers fall into lake	С	2	М
		C	Blisters	С	4	Н
			Workers injured by pieces concrete	В	5	E
			pile cutting			
	f.	Reinforcement work	Blisters	D	2	L
	g.	Formwork installation	Workers pinched by formwork	D	3	Μ
	-		Workers fall into lake	С	3	Н
	h.	Concrete work	Ready mix truck stuck	D	4	Н
			Concrete pump pipe is detached	С	2	Μ
			Irritant or allergic dermatitis	С	2	Μ
5.	Bo	red Pile Work				
	a.	Bore pile boring machines operating	Auger is detached from kelly bar	C	4	Н
		1 0	Noise	С	3	М
	b.	Casing installation	Welding machine rolled over the	С	2	М
		0	workers			
			Ground vibration	С	3	Μ
	c.	Reinforcement work	Blisters	D	2	L
	d.	Concrete work	Ready mix truck stuck	D	4	Н
			Concrete pump pipe is detached	С	2	Μ
			Irritant or allergic dermatitis	С	2	М

From the results obtained ranking above 4 types of risks to extreme risk, high risk, medium risk and low risk. Figure 1. presents the risk percentage, as follows extreme risk (16%), high risk (33%), medium risk (44%), and low risk (7%)



**Risk Percentage** 

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

**IOP** Publishing

## Figure 1: Risk percentage at Soekarno-Hatta International Airport Accessibility Project

The type of risk that requires risk control before the work begins. According to OHSAS 18001 [12], risk control activities through elimination control, substitution, engineering, administrative control, and Personal Protective Equipment (PPE). Risk control is carried out for all potential hazards that arise in any construction work. After determining the risk control of each potential hazard, a risk assessment is carried out again to ensure that the risk level has dropped. Low risk level is the level of risk that is still acceptable to the company, but the company must controling the level of risk regularly. In further explanation, the discussion will be limited to the extreme risk levels and how the company control the extreme risk.

No		Activity	Risk Control	Risk Assessment		Risk
				Likelihood	Severity	Level
1.	Sur	rvey			-	
	a.	Soil Investigation	Make sure the worker knows the project environment; put warning signs	D	1	L
			Making traffic management, flagman manages traffic	D	1	L
	b.	Heavy equipment mobilization	Make sure the operator condition is fit and has an operating license	Е	1	L
2.	Lar	nd Clearing				
	a.	Operating Heavy	Make sure the operator condition is		2	L
		Equipment	fit and has an operating license	С		
			Making equipment and tools inspection procedure; Inspection of equipment before work	D	2	М
			Create a safe working area for equipment	Е	1	L
			Operators coordinate with engineer and safety officer before work (toolbox meeting)	D	1	L
3.	Exe	cavation work				
	a.	Soil excavation	Make sure the operator condition is fit and has an operating license	D	1	L
			Operators coordinate with engineer and safety officer before work (toolbox meeting)	Ε	1	L
			Installation of project safety lines as work area boundaries	D	1	L
			Install warning signs and safety lines as loading and unloading areas	Е	1	L
	b.	Soil transportation	Make sure the operator condition is fit and has an operating license	D	1	L
			Installation of project safety lines as work area boundaries	Ε	1	L
			Operators coordinate with engineer and safety officer before work (toolbox meeting)	Ε	1	L
	c.	Soil compaction	Workers are required to use	D	1	L

Table 4. Risk Control at Soekarno-Hatta International Airport Accessibility Project

 IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048
 doi:10.1088/1755-1315/700/1/012048

No	Activity		Risk Control	<b>Risk Assessment</b>		Risk Level	
			contruction personal protective equipments				
	d.	Asphalts paving work	Workers are required to use contruction personal protective	Ε	1	L	
			Making traffic management,	D	1	L	
			Operators coordinate with engineer and safety officer before work (toolbox meeting)	Ε	1	L	
4	Pill	ing Work					
	a.	Tower crane and diesel hummer operating	Make sure the operator condition is fit and has an operating license	Ε	1	L	
			Making equipment and tools inspection procedure; Inspection of equipment before work	D	1	L	
			Making equipment and tools inspection procedure; Inspection of equipment before work	Ε	1	L	
	b.	Concrete pile pilling	Make sure the operator condition is fit and has an operating license	Ε	1	L	
			Put a flagman to direct the truck	Е	1	L	
			Socialization to local residents ; time adjustment for the pilling work	Ε	1	L	
	c.	Pile connection	Workers are required to use contruction personal protective equipments	Ε	Ι	L	
	d.	Bracket formwork installation	Workers are required to use contruction personal protective equipments	D	1	L	
			Make sure the worker knows the project environment; put warning	Ε	1	L	
			Make sure the pontoon / floor work is stable and the anchors is strong	D	1	L	
	e.	Pile Cutting	Make sure the worker knows the project environment; put warning signs	Ε	1	L	
			Workers are required to use contruction personal protective equipments	D	1	L	
			Workers are required to use contruction personal protective equipments	D	1	L	
	f.	Reinforcement work	Workers are required to use contruction personal protective equipments	Ε	1	L	
	g.	Formwork installation	Workers are required to use contruction personal protective equipments	D	2	L	
			Make sure the worker knows the project environment; put warning	D	1	L	

The 9th Engineering International Conference

**IOP** Publishing

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

No	No Activity		Risk Control	<b>Risk Assessment</b>		Risk Level
	h.	Concrete work	signs Put a flagman to direct the ready	Е	1	L
			Making equipment and tools inspection procedure; Inspection of	Е	1	L
			Workers are required to use contruction personal protective equipments	Ε	1	L
5.	Bo	red Pile Work	equipments			
	a.	Bore pile boring machines operating	Making equipment and tools inspection procedure; Inspection of equipment before work	D	1	L
			Socialization to local residents ; time adjustment for the boring machines operating	Ε	1	L
	b.	Casing installation	Workers are required to use contruction personal protective equipments	Ε	1	L
			Socialization to local residents; time adjustment for casing installation	Е	1	L
	c.	Reinforcement work	Workers are required to use contruction personal protective equipments	Ε	1	L
	d.	Concrete work	Put a flagman to direct the ready mix truck	Е	1	L
			Making equipment and tools inspection procedure; Inspection of equipment before work	Ε	1	L
			Workers are required to use contruction personal protective equipments	Е	1	L

Workers fall into lake presents an extreme risk. To avoid this risk, safety officer must have safety working procedures so that the worker knows the potential hazard at project environment and set up warning signs alongside work locations. The company also provide the workers additional Personal Protective Equipment (PPE) i.e. full body harness to mitigate the risk of falling into lake.

Workers get hit by road users. To handle this risk, it is essential to ensure that a flagman is in place to manage traffic flow and that safety signs and safety rails are installed during construction work. In addition, the safety officer is responsible for making reasonable traffic management to prevent traffic jam around the project site.

The operator is exhausted, there is also an extreme risk that the operator may experience fatigue while operating the equipment. To mitigate this risk, it must be ensured that the operator is in fit and healthy condition, both physically and mentally, and has no disease or disability. According to the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number: 08 Year: 2020 concerning lifting and hauling equipment [13], chapter VI about operator. One of the requirements of being a lifting and hauling equipment operator is to be in fit and healthy condition according to a doctor's statement. Operators of lifting equipment, must have a health certificate to ensure that operators do not have experience any fatigue when operating heavy equipment [14]. This certificate should be updated every year and also tests for visual acuity and color blind test, hearing test, muscle test, and drug test [15].

Crane wire rope failure, Wire rope that break at work have an extreme risk. According to the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number: 08 Year: 2020 concerning lifting and hauling equipment, the inspection frequency of slings can range from each day or shift, yearly, monthly to quarterly, and whenever an expert person suggests doing special service of slings. To mitigate this risk, it is important for engineers to always perform periodic inspection of slings before they work.

Vibro hummer failure. To mitigate this risk, the company should make equipment and tools inspection procedure [16]. It is to ensure that all systems are operating properly configured. Inspections should be performed daily or per manufacturer's specifications and also always inspect all equipment before work.

Workers pinched by bracket formwork and Workers injured by pieces concrete pile cutting both also presents an extreme risk. To mitigate this risk, workers should pay attention to the safety and use Personal Protective Equipment (PPE) i.e gloves, helmet, and shoes. Safety gloves serves to protect worker's hand from sharp objects, heat, chemicals, etc. Safety shoes serves to protect worker's foot crushed sharp or heavy objects, hot objects, chemicals, etc. Safety helmet, serves to protect worker's head from falling materials.

#### 5. Conclusion and Suggestion

The most extreme risk at Soekarno-Hatta International Airport Accessibility Project, are: (i) Workers fall into lake. The risk control is to ensure the worker knows the project environment; put warning signs and making traffic management; (ii) Workers get hit by road users. To control this risk, the project should establish a flagman to manages traffic; (iii) The operator is exhausted. The risk control is to ensure the operator condition is fit and also has an operating license; (iv) Crane wire rope failure. To control this risk, the engineers should commit periodic inspection of slings before they work; (v) Vibro hummer failure. To control this risk, safety officer should have equipment and tools inspection procedure; and doing inspection before they work; (vi) Workers pinched by bracket formwork and (vii) Workers njured by pieces concrete pile cutting. The risk control for both risk is to ensure that workers use contruction personal protective equipments i.e gloves, helmet, and shoes.

#### Reference

- [1] Farrita I, Kamar M and Ahmad A C 2016 A Conceptual Framework of Safety and Health in Construction *Management* **00107**
- [2] Guo HL, Li H, and Li V 2013 Automation in Construction VP-based safety management in large-scale construction projects : A conceptual framework *Autom. Constr* **34** 16–24
- [3] Chong HY, Low TS, and Chong HY 2014 Accidents in Malaysian Construction Industry: Statistical Data and Court Cases Accidents in Malaysian Construction Industry Statistical Data and Court Cases Int J Occup Saf Ergon 20 503-513
- [4] Darda A, Napiah M, Othman I, Miki M, and Al-ashmori YY 2020 Rate of Occurrence of Fatal Accidents in Malaysian Construction Industry after BIM Implementation International Journal of Engineering and Management Research 10 49–76
- [5] Barrie A, Rohani JM, Kidam K, and Ismail M 2020 Risk Assessment of Design Components of Building Construction Risk Assessment of Design Components of Building Construction IOP Conference Series Materials Science and Engineering 884 012046
- [6] Ahmad AC, Farrita I, Kamar M, Muhaimin A, and Wahid A 2019 Risk Assessment Of Piling Work For Mass Rapid Transit (MRT) Construction Project Geographia Technica 14 232– 241
- [7] Ahmad AC, Mohd Zin IN, Rosli MN, Ab Wahid AM and Mohd Kamar IF 2016 Hazard and Risk of Highway Maintenance Works: Case Study of PLUS Expressways MATEC Web Conf 66 00106
- [8] Chi S and Han S 2013 Analyses of Systems Theory for Construction Accident Prevention With

.

IOP Conf. Series: Earth and Environmental Science 700 (2021) 012048 doi:10.1088/1755-1315/700/1/012048

Specific Reference to OSHA Accident Reports International Journal of Project Management **31** 1027–1041

- [9] Ozdemir Y, Gul M, and Celik E 2017 Assessment of Occupational Hazards and Associated Risks in Fuzzy Environment : a Case Study of a University Chemical Laboratory Human and Ecological Risk Assessment: An International Journal 23 895-924
- [10] PT. X 2019 Safety, Health, Environmental Plan Procedure
- [11] Pinto A, Nunes IL, and Ribeiro RA 2011 Occupational Risk Assessment in Construction Industry – Overview and Reflection *Saf. Sci.* **49** 616–624
- [12] Anonymous 2007 Occupational Health and Safety Management Systems-Requirements (London: OHSAS Project Group)
- [13] Anonymous 2020 Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number 08 Year 2020 Concerning Lifting and Hauling Equipment (Jakarta: Minister of Manpower and Transmigration of the Republic of Indonesia)
- [14] Tam VWY and Fung IWH 2011 Tower crane safety in the construction industry : A Hong Kong Study Saf. Sci 49 208–215
- [15] Hapsari A, Erwandi D, and Syam AF 2018 Risks Control for Launching Gantry Activity Assembly at Kapten Tendean Flyover Project (Seskoal Package) KnE Life Sciences 4 159– 173
- [16] McCann M 2006 Heavy Equipment and Truck-Related Deaths on Excavation Work Sites Journal of Safety Research 37 511–517