Occupational Safety and Health Risk Analysis on Skycrapers Construction Projects in the Jakarta

Ia Asih and Hernadewita
Master of Industrial Engineering
Universitas Mercu Buana
Jl. Meruya Selatan No.1 Kembangan, Jakarta 11650, Indonesia
drgiaasih@yahoo.com, hadeita@yahoo.com

Hendra
Faculty of Mechanical Engineering
Universitas Sultan Ageng Tirtayasa
Banten, Indonesia
hendra@untirta.ac.id

Abstract

Construction work is the complexity of work involving building materials, equipment, the application of technology, and labor. The Construction Sector is the largest contributor to the accident rate in Indonesia. percent. To reduce the occurrence of occupational accidents and occupational diseases, it is necessary to identify, assess and analyze the safety and health risks of the construction sector. This study aims to analyze the risks of work at the height that causes work accidents. This research was conducted observationally on the construction of skyscrapers buildings in the period April to June 2021. This research is carried out through the stages of risk assessment identification and preparation of risk priorities, root cause analysis of risk priorities, and formulation of recommendations for risk control and occupational hazards working at height. The results of the study found hazards that threaten the safety and health of workers based on risk assessments with categories of 41.18% low risk, 52.94% moderate risk, and 5.88% high risk.

Keywords
Construction, Occupational Safety and Health (OSH), Risk Analysis, Root Cause Analysis.

1. Introduction

Based on employment guarantee agency data, from the total number of cases of work accidents that occurred in Indonesia, which amounted to 177.000 cases in the year 2020. The construction sector is the highest contributor to the accident rate. Construction accidents include building project work, roads, bridges, tunnels, dam irrigation, and others. Construction workers do a lot of work at high heights such as working using heavy equipment cranes, iron installation, roof, ceilings, electrical and plumbing installations, elevators, etc. The International Labor Organization (ILO) says that although occupational diseases kill six times as many people, accidents attract greater attention, of the 2.34 million annual work-related deaths, about 2.02 million are caused by work-related illnesses. This represents a daily average of 5,500 deaths. The ILO also estimates 160 million cases of work-related non-fatal diseases occur each year (ILO, 2013).

Accidents in the construction sector involving high-height work (Fass et al., 2017) accounted for 47% of all accidents, arm injuries by 29%, legs by 26%, and Fractures by 47%. The cause of accidents that most often occur is falling from stairs, and roofs, for body parts that often suffer injuries are feet that are hit by material, concrete structures, excavators occur most often. (Yang et al., 2016). The effects of accidents on the construction sector resulted in 48.57% loss of working time, 22.86% of company reputation, 14.29% of worker psychology, 11.43% of medical expenses, 2.85% of others (Zairani et al., 2020).

The occupational safety and health (OSH) application is very important to create a safe, healthy and comfortable working environment and achieve zero work accidents, the role of the construction supervisor is very important in identifying all hazards in the construction sector (Perlman et al., 2014). Hazard identification and risk assessment is one of the approaches taken to prevent work accidents and occupational diseases in the workplace, determining appropriate work procedures by conducting hazard analysis in the work area. The results of the analysis can be used to reduce risk, reduce the frequency of work accidents, reduce worker absences, lower workers' compensation costs, and increase productivity (Kurniawan & Kurniawan, 2020). Work procedures and risk management are related to the commitment of OSH organizations (Kaynak et al., 2016) that can reduce workplace accidents and increase employee productivity.

Based on research (Hakim, 2017) from risk assessment, falling from a height has the highest risk of scaffolding unloading activity. The nature of the injury is a determinant of possible safety risks along with the type of the injury that occurs (Kakhki et al., 2019), with OSH risk measurements can prevent work accidents, save lives and decrease the frequency and severity of work accidents. Modeling conducted by (Aneziris et al., 2008) has measured the likelihood of falling from stairs, roofs, scaffolding, holes in the ground, moving platforms, and immobile vehicles with possible consequences of falls such as death, permanent injury, and non-permanent injury.

1.1 Objectives
The aim of this study is to analyze the risk of occupational accidents and formulate recommendations for the tallest building construction project in Indonesia through a work safety risk management review.

2. Literature Review
2.1 Occupational Safety and Health (OSH)
Occupational Safety and Health is a protective effort aimed at protecting workers and others who are at work to always be safe, healthy, and comfortable. Based on Law Number 1 of 1970 and Government Regulation number 50 of 2012 companies that employ workers at least 100 (one hundred) people or have a high level of potential danger. The construction sector which employs more than 100 must implement an Occupational Safety and Health Management System (OSMS) which includes organizational structure, planning, responsibility, implementation, procedures, processes, resources needed for the development of the implementation, achievement, assessment, and maintenance of OSH policies for the creation of a safe, efficient, and productive workplace. While in the Regulation of the Minister of Public Works No. 05 / PRT / M / 2014 on Guidelines for Occupational Safety and Health Management System (OSMS) Construction in the Field of Public Works Article 19 letter J on The duty of responsibility of service providers: "Carrying out risk control of OSH construction, including inspections that include" 1. Workplace 2. Work equipment 3. How it works 4. Work Protective Equipment 5. Personal Protective Equipment (PPE) 6. Signs and 7. Construction work environment in accordance with the contract OSH plan the implementation of OSMS aims to increase the effectiveness of planned, structured, structured, and integrated OSH protection. Prevent and reduce occupational accidents and occupational diseases by involving management, workers, or laborers. One of the criteria in OSH audit is 2.1.1, namely documented procedures for the identification of potential hazards, assessment, and control of 3 risks. The application of OSH requirements working at a mandatory height must be implemented by the construction company as stipulated in Ministry of Manpower regulation number 9 of 2016.

2.2 Job Safety Analysis
Job Safety Analysis is a safety management technique that focuses on hazard identification and risk control, which is used to reduce potential hazards in the work brake (Sharma & Suryawanshi, 2017) which consists of several stages, namely identifying specific work steps from start to finish of work, identifying hazards that can occur at each step of work and determining Hazard-based control measures on each predetermined work measure to reduce or eliminate hazards. According to Rozenfeld et al. (2010) each step of JSA's work focuses on the relationship between tasks/work, equipment, and the work environment. The benefits of JSA are job formalization, retrospective and prospective accountability, worker participation and work outcomes, means of learning practice, increased vigilance, and preventing harm (Albrechtsen et al., 2019)

2.3 Risk Analysis
The analysis is an activity that describes a risk by determining the magnitude of probability and severity of the consequences of a risk of harm. Risk analysis is very important in construction projects. Risk analysis is considered

the worst possible outcome that can occur both at the planning, and execution stages. (Dziadosz & Rejment, 2015). Risk management whose main purpose is to manage risk to prevent accidents or unwanted events through the process of hazard identification, risk assessment, and control. (Purohit et al., 2018). Table 1 intepreted of likelihood type, Table 2 intepreted type of severity and Table 3 intepreted of risk level and action level.

Table 1. Likelihood Type

Levels	Criterion	Qualitative Description	Semi-Quantitative
1	Maybe	Accidents can in theory happen but are impossible.	Less than once in five years
2	Low	Accidents are rare.	Occurs once per 5 years
3	Keep	Accidents happen once a year.	1 time per 3 years to 1 time per year
4	Tall	Accidents almost occur monthly or per three months	More than 1 time per year to 1 time per month
5	Extreme	Accidents often occur from day to month.	More than once per month

Table 2. Type of Severity (Consequences)

Levels	Criterion	Qualitative Description	Semi-Quantitative
1	None	The incident did not cause any harm or injury to humans.	It doesn't cause a loss of the day.
2	Low	Cause minor injuries, minor losses and do not cause serious impacts on business continuity	You can still work the same day/shift.
3	Serious	Severe injuries and hospitalization, causing no permanent disability, moderate financial loss	Lost workdays under 3 days
4	Vulnerable	Causing severe injuries and permanent disabilities and large financial losses and causing serious impacts on business continuity	Lost workday 3 days or more
5	Plagues	Resulting in death and severe losses can even stop business activities forever	Lost the workday forever

Table 3. Risk Level and Action Level

Risk Level	Action Required
1-5	Low
6-21	Medium
14-22	High
23-25	Very High

Risk assessment is carried out on the entire analysis process (identification and forecast) as well as risk evaluation (measurement and tolerance). Risk assessment can be defined as a kind of risk assessment process with respect to any construction hazard identified. Assessments can be made in structured discussions, consultations or formal meetings. Risk assessments contain identified hazard information that can be reviewed or updated periodically as construction work progresses. In addition, risk assessments need to be carried out systematically so that the person in charge of the construction site i.e. the project manager and the OSH expert can resolve whether they have taken adequate precautions or should take more control measures to prevent harm.

3. Methods

This research is a descriptive study with a short of qualitative where the research object consists of work, place, and activity. To investigate various characteristic of hazard and consequences during work at height activity in construction site, this research using hazard identification and risk analysis method. This method taken to mitigate or reduce accident in the future.

4. Data Collection

The research site is the construction project. This construction designed as the tallest building construction in Indonesia which has 75 floors with a height of 382,9 meters. Data collection techniques used are direct observation to the project work environment, documentation review of related documents, interviews, and conducting risk assessments. Workers in this study include SHE personnel, foreman, and representatives of field workers (construction workers) that's 67 whose work at height. The study was conducted from April to June 2021.

5. Results and Discussion

5.1 Inspection and Incident Data

Based on OSH inspection data in 2020, the most findings were the danger of people falling poor housekeeping, the danger of tripping or slipping, and the danger of falling goods, while the incident report from January 9, 2018, to June 25, 2019, where there were 16 incidents with details of 37.5% falling from a height or falling from the same surface or falling objects, 18.75% contact with rough objects (slashed, punctured, sharp, hit), 18.75% hit something and 6.25% excess load lifting. Of the 16 incidents, 43.75% suffered property damage, 37.5% needed first aid action, 12.5% were near misses, and 6.25% needed further treatment.

5.2 Risk Identification

Results of identification of occupational safety risks that have been done by researchers through three methods, namely direct observation to the project work environment, review of documentation of related documents and interviews with workers can be seen in Table 4

Table 4. Work Activities at Height

No.	Activity	Description of Risk
1	Assembly/installation/splicing of iron stake (forming working) at height manually	Workers fall from a height Slip Fingers pinched when tightening bolts/ iron Impaled
2	Installation and demolition of scaffolding	Falling from a height Slip Fingers pinched when tightening bolts/ iron Collapsed structure Bumped into structure
3	Installation of column ring	Sharp part Falling objects Stuck Falling from a height
4	Demolition of cast pads	Fall from a height Slip Pinched finger Scratched Hit by a falling object Being in an unsafe position at the time of demolition (awkward position)
5	Manual lifting of goods (wood, triplets, scaffolding, iron, Hebel) manually.	Wrong position at the time of lifting Excess load
6	Light brick installation/foundry/column installation	Fall Material spill Hit by an object
7	Wall coating work with plaster and aci	Cement dust Material spill
8	Installation of sled room, cabin, engine and elevator installation	Fall Hit by something Electrical

9	Poor working environment (less lighting, hot working climate)	Tired eyes Dehydration
10	Poor House Keeping	Slip Falling from a flat form Falling from the sloping Stumble

Based on table 1 it can be known that each stage of work activity at height has risks that can cause losses both to workers, loss of working hours, damage to facilities and materials.

5.3 Risk Assessment

Risk assessment is done to determine the magnitude of a risk that has been identified so that it is used to determine control priorities on the level of risk of occupational accidents or diseases. The results of the occupational safety risk assessment based on the degree of likelihood and severity with the help of the risk matrix are presented in Table 5. According to table 5, there is a 41.18% low risk, 52.94% moderate risk, and 5.88% high risk. A risk that can still be tolerated by companies in accordance with AS / NZS 4360 (2004) is a risk with a low to moderate value, therefore the risk that is the focus in priority preparation is the risk with high-risk index value and extreme as shown in table 2. The root cause of the occupational safety risk is divided into two, technical and non-technical. The root of technical problems deals with machine or tool factors, materials, and the environment while non-technical factors relate to human factors. Based on root cause analysis of incidents that have occurred, it is known that human factors are the basic cause of accidents at this Construction Project, which include: fatigue, inning-and-lack of understanding of work procedures, and a lack of worker awareness of the importance of implementing OSH in the workplace.

5.4 Risk Control

Control of the risk of accidents and diseases due to work is done through hazard identification by considering conditions and events that can cause harm, types of accidents, and diseases due to errors that may occur.

1. Reduce Likelihood or Severity

Reduce likelihood and severity is the most relevant approach to do where this approach is done by reducing the likelihood or severity of an incident, risk control at the level of the unit of activity or project is more technical and direct in their respective workplaces. The risk management process is carried out in detail for each activity, process, worksite, or equipment. Based on Ministry of Manpower regulation number PER.01/MEN/1980, every construction work must prevent accidents or pain due to labor to its workforce, OSH committee must be formed when the work begins. This OSH committee conducts prevention efforts against accidents, fires, occupational diseases, first aid in accidents, and rescue efforts. The application of OSH in the construction sector must be applied by the contractor board, the leader of the implementation of the work or sub-contractor in accordance with the Joint Decree of the Minister of Manpower and Minister of Public Works number KEP 174/MEN/1986. The role of OSH management is very important in providing knowledge of safe work procedures and the implementation of OSH implementation (Yiu et al., 2019). Lack of commitment from management in implementing OSH and lack of awareness of OSH can reduce safety behavior and increase the incidence of work accidents (Zahoor et al., 2016).

Lack of awareness of workers in workplace safety is one of the causes of construction work accidents (Biswas et al., 2017). Supervision of construction projects is very much needed, the presence of a construction OSH Expert in conducting risk assessments, managerial skills and conducting inspections and supervision in the field, making work accident reports, conducting work accidents studies can reduce incident rates, Construction OSH Experts as supervisors have an important role in providing coaching, mentoring, and supporting the needs of workers (Armstrong, 2010). The application of OSMS must be carried out both at the pre-construction stage and during construction implementation.

The risk control process at the project level is more technical in nature and is developed in accordance with the operating conditions in the work unit or project and is in direct contact with the hazard source. Risk control can be carried out through an approach to risk control principles based on a hierarchy of elimination, substitution, engineering control, administrative control, and the use of PPE (Sharma & Suryawanshi, 2017). Other controls can be done through

ventilation, application of hygiene and sanitation, education and training, incentives, rewards and motivation, evaluation through internal audit, incident investigation (Ismail et al., 2012), law enforcement.

2. Safe work procedures and work instructions
It is very important that the appropriate work standards (SOP) are set and disseminated to all workers, work instructions must be implemented and reviewed periodically if there is a change in equipment, processes, or raw materials by involving competent personnel. The provision of competent personnel through the provision of OHS training and first aid facilities with emergency response facilities is required for handling incidents that may occur.

3. Risk Transfer
Submission of part of the implementation of the work to another company or third party must ensure that the company understands OSH construction and has a competent workforce. OSH risk in any field, especially in the construction sector, cannot be completely eliminated, so to reduce the risk burden borne by the contractor, risk control by risk transfer is still deemed necessary to be carried out. Companies and third parties are required to include all workers in employment guarantee insurance. This is in accordance with Law number 24 of 2011 concerning the Social Security Administering Body and the Minister of Manpower Number 5 of 2021 concerning procedures for implementing work accident insurance programs, death benefits, and old-age benefits, where workers in the construction sector are both casual daily workers and casual workers. or workers with a certain time agreement are entitled to protection against work accident insurance and death insurance. Construction project managers must know the common causes of accidents in the workplace so that they can identify risk factors early to make prevention efforts (Yakubu & Bakri, 2013).

6. Conclusion
Based on the results of hazard identification and risk assessment, 441.18% low risk, 52.94% moderate risk, and 5.88% high risk. High-risk results are obtained at the stage of plastering and covering wall coating work, while the potential hazards that arise at all stages of work are falling from a working height, namely: workers falling from a height. Based on the root cause analysis of the incidents on the XYZ project which are prioritized, it is known that the dominant basic causes are human factors, namely: work fatigue, workers lack of experience and lack of understanding of work procedures, as well as lack of awareness of workers on the importance of implementing K3 in the workplace.

For this reason, it is necessary to measure the level of fatigue, work time arrangements (Nadhim et al., 2016), application of SOP (Borys, 2012), socialization of safe work procedures, use of fall arrest devices for work with a height of more than 6 feet, provision of fences barrier, safety net system or individual fall arrest (OSHA, 2015), increased knowledge, awareness, communication (Ismail et al., 2012) and worker skills through training (Pham et al., 2018) as well as certification, increased supervision (Smith & Pillarisetti, 2017), working at heights with the risk of falling from a height is still the single biggest cause of death on-site and in the workplace. Third parties (subcontractors) working at heights must understand the root causes of falls from a height and propose effective practical measures to reduce the number of serious injuries and deaths from falling from heights (Group & Inquiry, 2019) in an effort to create zero accidents and improve productivity (Sukamani & Wang, 2020). Supervision is not only carried out by the company but also by the government.

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Biographies

Ia Asih is a graduate student in Magister Industrial Engineering at Mercu Buana University, Jakarta. Her research interests include Occupational Safety and Health, Ergonomic, Work Accident, and Productivity. She graduated with a bachelor's degree from the Faculty of Dentistry in 1998 from the University of Indonesia, Jakarta. She currently works as senior Labor Inspector Of OSH at the Ministry Manpower of the Republic Indonesia.

Dr. Hernadewita, M.Si is an Associate Professor in industrial engineering; major subject in Quality, Productiviy and System Methodology at University Mercu Buana Jakarta. Her research interest included quality operations, modern quality management such as Lean and Green Manufacturing, Lean Six Sigma, etc. She graduated in Industrial Engineering in 1992, M.Si. from University of Indonesia 2002, and obtained PhD in 2013 from University Kebangsaan Malaysia.

Dr. Eng. Hendra, S.T., M.T., is an Associate Professor in Mechanical Engineering Departement Universitas Sultan Ageng Tirtayasa Banten Indonesia. His research interest in the manufacturing process, vibration on machine tools, finite element method to stress of structure and etc. He graduated in the Mechanical Engineering Universitas Andalas Padang in 1999, Master of Engineering field in Mechanical Production Engineering from Institute of Technology Bandung Indonesia in 2003, and Doctor Engineering field in Mechanical Engineering from Kyushu Institute of Technology Japan in 2010.

Table 5. OSH Risk Assessment Results Work at Height

No.	Job Description	Potential Danger	Health Risks	Likelihood	Consequences	Risk	Risk Level	Control
1	Assembly/installation/splicing of iron stake (formworking) at height manually	Falling from a height	Fractures	1	4	4	Low	SOP, PPE
		Slip	Sprain	2	3	6	Keep	Installation of a working positioning device
		Fingers pinched when tightening bolts/ iron	Torn wounds	3	3	9	Keep	Glove
		Impaled	Torn wounds	3	3	9	Keep	Glove
2	Installation and demolition of scaffolding	Falling from a height	Fractures	1	4	8	Keep	SOP, PPE
		Slip	Sprain	2	3	6	Keep	SOP
		Fingers pinched when tightening bolts/ iron	Torn wounds	3	3	9	Keep	Glove
		Collapsed structure	Bruised, pierced	1	3	3	Low	SOP, Scaffold Technician
		Bumped into structure	Bruise	3	2	6	Keep	SOP
3	Installation of column ring	Sharp part	Scratched	3	2	6	Keep	Glove
		Falling objects	Bruise	2	2	4	Low	SOP, Safety Helmet
		Stuck	Torn wounds	3	2	6	Keep	SOP, Gloves
		Falling from a height	Fractures	1	4	4	Low	PPE
4	Demolition of cast pads	Falling from a height	Fractures	1	4	4	Low	PPE
		Slip	Sprain	2	2	4	Low	SOP
		Pinched finger	Torn wounds	3	2	6	Keep	SOP
		Scratched	Torn wounds	3	2	6	Keep	Glove
		Hit by a falling object	Bruise	2	2	4	Low	SOP
		Being in an unsafe position at the time of demolition (awkward position)	Fatigue	3	2	6	Keep	SOP
5	Manual lifting of goods (wood, triplets, scaffolding, iron, hebel)	Wrong position at the time of lifting	Sprain	2	2	4	Low	SOP
		Excess load	Sprain	2	2	4	Low	
6		Fall	Fractures	1	2	2	Low	SOP, PPE
		Material spill	Skin irritation	5	2	10	Low	Glove

	Light brick installation/foundry/column installation	Hit by a thing	Bruise	2	4	8	Keep	SOP
7	Plaster and Layering Wall Work	Cement dust	Eye irritation	5	3	15	Tall	Glasses
		Material spill	Skin irritation	4	4	16	Tall	Glove
8	Installation of sled room, cabin, engine and elevator installation	Fall	Fractures	1	4	4	Low	PPE
		Hit by a thing	Bruise	1	3	3	Low	SOP
		Electrical	Electric shock	1	4	4	Low	SOP
9	Poor working environment (poor lighting, hot working climate)	Tired eyes	Watery/tired eyes	4	2	8	Keep	Addition of lights
		Dehydration	Faint	4	2	8	Keep	Drinking water supply
10	Poor House Keeping	Slip	Sprain	2	3	6	Keep	5S
		Falling from a flat lead	Sprain	2	3	6	Keep	5S
		Falling from the sloping	Bruise	2	3	6	Keep	5S
		Stumble	Sprain	2	1	2	Keep	5S