Periodicals of Occupational Safety and Health
Vol. 3, No. 1, Maret 2024, pp. 1-10 e-ISSN: 2962-584X

Identification of Occupational Health and Safety Hazards In Formwork Fabrication Area of Building Construction Project

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ARTICLE INFO

Article history
Received February 3, 2024
Revised February 20, 2024
Accepted Marc 10, 2024

Keywords
Occupational Health and Safety
Hazard Identification
Risk
Formwork fabrication
Building Construction

ABSTRACT

Background: Potential hazards are a threat to the safety and health of workers. Formwork fabrication as a woodworking area to create molds that will be used for the casting process of columns, beams and plates is not spared from potential hazards. Initial observations reveal some potential hazards that are of interest to be further identified. This study aims to identify potential hazards in the formwork fabrication area. The benefit is that it can be the basis for assessing risk and determining appropriate control determinants; **Method:** This type of research is a descriptive survey with an observational approach. The method used is a Walkthrough Survey with a hazard identification sheet instrument. Hazard identification is carried out based on UURI Number 1 of 1970 and PPRI Number 50 of 2012, namely identifying potential hazards sourced from humans, production materials, equipment, machinery, working methods and work environment; **Results:** Unsafe action; The use of materials that are large, heavy and have sharp edges; The use of hammers, saws, rotation of grinding blades, sparks, use of electrical connectors is not feasible; Works without structured flows and procedures; Vibration, noise, heat pressure, dust, fecal coliform, mosquitoes, centipedes, unstructured workstation layout, awkward posture, manual handling, and repetitive body movements are some of the potential hazards that have been successfully identified; and **Conclusion:** Each potential hazard has its own risk that has not been assessed in this study. Likewise, the determinants of its control have not been included in this study. For this reason, further research is needed to assess risks and determine control determinants based on the potential hazards that have been identified in this study.

How to citate:
Zulhayudin, M. F., & Razzak, A. (2024). *Identification of Occupational Health and Safety's Hazards in Formwork Fabrication Area of Building Construction Project.* Periodicals of Occupational Safety and Health, *3*(1), 1–9. https://doi.org/10.12928/posh.v3i1.11616

1. Introduction

Every workplace must have various potential hazards that can risk harming, injuriating, hurting and even killing workers and non-workers and at risk of causing fire, damage and pollution (UURI, 1970). Hazard is any source of loss. Meanwhile, risk is the opportunity for loss if exposed or exposed to hazard (CCOHS, 2020). Hazards can be sourced from human conditions and actions, production materials, equipment, machinery, working methods and work environment (Leka & Jain, 2010; PPRI, 2012; Wong et al., 2019). Meanwhile, risk is the opportunity to lose if exposed or exposed to hazard. The chance of loss can be assessed through a calculation between the likelihood and consequences of the identified hazard (Zulhayudin, 2023). Hazard is any source of loss. Meanwhile, risk is the opportunity to lose if exposed to hazard.

The construction sector is one of the most hazardous workplaces in the world that is at great risk of harming its workers. The accident rate in the construction industry is among the highest compared to other industries worldwide (Martínez-Rojas et al., 2020). Directly, of course, the cause of these various accidents is due to various potential hazards that are out of control. Meanwhile, indirectly, work accidents can be caused by a lack of worker competence which includes knowledge, skills and experience. In addition, it can also be caused by the company's management factor that does not have a commitment to the implementation of OSH in the workplace.

Formwork fabrication is a woodworking area to make molds that will be used in the casting process of columns, beams, plates and parts of (Jipa et al., 2019). The number of workers in the area is 8-10 workers who work from 08.00 to 17.00 with a break time of 12.00 to 13.00. This means that iron fabrication workers work for 8 hours/day plus 1 hour of rest time.

The results of initial observations showed potential hazards in formwork fabrication such as scattered nail wood pieces, the use of cutting machines, repetitive movements, awkward postures, and exposure to direct sunlight which attracted researchers to further identify potential hazards in formwork fabrication for the IPC Unika Building construction project by PT Adhi Persada Gedung.

2. Materials and Method

The research was carried out in the iron fabrication area in the construction project of the Semarang IPC Unika Building by PT Adhi Persada Gedung. This type of research is a descriptive survey with an observational approach. The method used is *a* Walkthrough Survey with a hazard identification sheet instrument. Hazard identification is carried out based on Law of the Republic of Indonesia Number 1 of 1970 and Government Regulation of the Republic of Indonesia Number 50 of 2012, namely identifying potential hazards sourced from humans, production materials, equipment, machinery, working methods and work environment. The purpose of this study is to identify various potential hazards in the iron fabrication work area. The benefit of this research is that it can be the basis for assessing risk and determining appropriate control determinants.

3. Results and Discussion

3.1. Results

3.1.1. Hazard Identification from Human Resources

Table 1. Hazard Identification from Human Resources

Work Area	Source of Hazard	Hazard Explanation	Risk
Formwork Fabrication	Human	Unsafe Action: 1. Workers do not check tools and machines before use	1. Engine failures that can lead to sharing types of accidents
		2. Workers do not apply the 5R principle	1. Workers find it difficult to find and reach for work tools so that they can slow down production time
		3. Workers do not use helmets, masks and gloves	1. Inhalation of wood dust will gradually cause lung disorders
		4. Workers smoke in a pile of wood chips	1. There is a high potential for fires

Potential hazards from human sources that have been identified are unsafe actions. The first *unsafe* action is that the worker does not use a proper helmet. The risk that can occur is that at any time the helmet can come off the head so that there is no protection when there is a head impact. *The second* unsafe action is that the worker does not apply the 5R principle. The risk is that workers find it difficult to find and reach for work tools so that they can slow down production time. The third potential hazard is that workers do not wear masks. The risk that can occur is inhalation of wood dust and inhalation of smoke from the engine which will gradually cause lung disorders. The fourth potential hazard is workers smoking in piles of wood powder

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3.1.2. Hazard Identification from the Source of Production Materials

Table 2. Hazard Identification from the Source of Production Materials

Work Area	Source of Hazard	Hazard Explanation	Risk
Formwork Fabrication	Production materials	1. The use of large and heavy production materials such as wooden blocks of various sizes.	1. Scratched and pinched wood
		2. Use of sharp materials such as nails and sticks	1. Punctured by nails and bumps

The potential hazard from the source of production materials that have been identified is the use of large and heavy production materials such as logs of various sizes. The risk that can occur is being scratched and pinched. The second is the use of sharp materials such as nails and sticks that risk piercing the skin of workers

3.1.3. Hazard Identification from Tool and Machinery Sources

Table 3. Hazard Identification from Tool and Machine Sources

Work Area	Source of Hazard	Hazard Explanation	Risk
Formwork Fabrication	Tool	1. The use of hammers, saws and bender pliers	1. Hit by a hammer, scratched by a saw and pinched by pliers
	Machine	1. Blade rotation from a grinding machine that does not have a safety *guard* 2. Sparks 3. Improper use of electrical connectors	1. Cutting off body parts 2. Uncontrolled sparks can hit the skin and hit wood dust 3. Electrocuted and short-circuited to fire

Potential hazards from the identified sources of tools and machines are the use of hammers, saws and bent pliers that risk hitting, scratching and pinching workers. The brittleness is a potential hazard in the form of blade rotation from a grinding machine that does not have a safety *guard* and the use of improper electrical connectors. The risk is the presence of uncontrolled sparks, blades that can cut parts of the body and electrocution and fire. Uncontrolled sparks are also a hazardous hazard that hits the skin and splashes into wood dust in the surrounding area.

3.1.4. Hazard Identification from the Source of the Working Method

Table 4. Hazard Identification from the Source of Work Methods

Work Area	Source of Hazard	Hazard Explanation	Risk
Iron Fabrication	Working Method	There is no clear and structured work flow and procedure specifically for formwork fabrication work	1. An irregular workflow will make work less efficient 2. Working without procedures can lead to production failures

The potential hazard of the identified source of work methods is the lack of clear and structured work flows and procedures specifically for formwork fabrication work. This hazard risks making work less efficient and potentially causing production failures.

3.1.5. Hazard Identification from Work Environment Sources

Table 5. Hazard Identification from Work Environment Sources

Work Area	Source of Hazard	Hazard Explanation	Risk
Formwork Fabrication	Work Environment	a. Physical Factors: 1. Vibration from the grinding machine 2. Noise from grinding machines 3. Solar heat temperature >35°C	1. *Carpal Tunel Syndrome* (CTS) due to vibration 2. Noise-induced hearing loss 3. *Heat edema, heat cramps, heat syncope, heat exhaustion* and *heat stroke* due to excessive heat exposure
		b. Chemical Factors: 1. Wood dust	1. Dust is inhaled or ingested so that there is a risk of contracting pnemococcosis.
		c. Biological Factors 1. *Fecal coliform* in dry soil 2. Mosquito 3. Centipede	1. Diarrhea, intestinal inflammation, urinary tract and biliary infections due to *fecal coliforms* 2. Malaria and Dengue fever due to mosquito bites 3. Infection due to centipede bites
		d. Ergonomic Factors 1. The layout of the workstation does not match the production flow 2. Awkward posture for a long time 3. Manual lifting and pulling activities with heavy material loads 4. The movement repeats for a long time	1. Irregular layout can reduce production efficiency 2. The hazards in numbers 2-4 can cause musculoskeletal disorders in workers

Potential hazards from sources of the work environment include physical, chemical, biological, and ergonomic factors. The first that has been identified from the physical factors is the vibration and noise of the grinding machine. The risk that can occur is *Carpal Tunel Syndrome* (CTS) due to vibration and hearing loss due to noise. Solar heat temperatures >35°C can be at risk of *heat edema, heat cramps, heat syncope, heat exhaustion* and *heat stroke.* The second is the chemical factor that has been identified, namely wood dust that is at risk of contracting pnemoconiosis or lung disorders. The third is the biological factors that have been identified, namely fecal coliform in dry soil which is at risk of diarrhea, intestinal inflammation, urinary tract infections and biliary tracts. Furthermore, there are mosquitoes whose bites cause malaria and dengue fever, as well as centipedes whose bites are at risk of causing infection. The fourth is ergonomic factors which include irregular workstation layouts that can reduce production efficiency and also awkward posture, manual lifting and pulling on heavy objects and repetitive movements for a long time can cause musculoskeletal disorders.

3.2. Discussion

3.2.1. Sources of Hazard from Humans

In the construction industry, about 80–90% of accidents are caused by *unsafe action* by employees. Thus, behavior management plays a key role in improving safety. In particular, behavioral

observation is the most important element for modifying worker behavior in a safe way (Hung & Su, 2021). The use of a helmet when working in a workplace with high potential hazards such as the construction sector is an absolute obligation. In its use, it must be in accordance with the applicable standard SNI ISO 3873:2012 (SNI ISO 3873:2012, 2012). The condition of the helmet should be checked at all times. To detect workers who do not use helmets, it can be done by utilizing technology *You Only Look Once* (YOLO) processed using *Convolutional Neural Network* (CNN) (Mailoa & Santoso, 2022). Furthermore, the use of gloves must be in accordance with the type and nature of the work being done. Referring to ANSI/ISEA 105-2016 and EN388, knitted gloves are not suitable for use in construction work (ANSI/ISEA 105-2016, 2016; BS EN 388:2016+A1:2018, 2019). If the job is to grasp hard, dense and textured objects, then the recommended gloves that can be worn are those made of cotton coated with composite rubber (Zhao et al., 2021).

3.2.2. Sources of Hazards from Production Materials

Heavy metals, which by definition, are trace elements with a high density of at least five times the density of water, are widely detected in indoor environments and buildings. Heavy metals such as iron dust, lead, cadmium (Sabouhi et al., 2020). Exposure of A549 cell lungs to silica-coated iron oxide nanoparticles (Fe3O4@SiO2-SH) results in severe disruption of actin microfilaments and cytoskeleton microtubules and reduces the size of focal adhesion (Královec et al., 2020). Until now, the use of iron for high-rise building structures has not been eliminated or substituted for its existence, so the risk of exposure to silica dust from iron will continue.

3.2.3. Sources of Hazard from Tools and Machinery

The use of manually driven tools and machines that move vertically, horizontally or in rotation is a hazard to the workers who use them. Pinched and cut body parts are a risk that can occur due to interaction with moving tools and machines. The use of manual tools such as hammers and saws has a number of significant hazards and safety risks if not used correctly. Improper use of a hammer can lead to injuries such as pinched fingers, bruises, or even broken bones due to mistargeting or bouncing of the hammer head. Meanwhile, the use of a saw, whether manual or electric, can lead to serious cuts, amputations, or injuries due to slipping or mistakes in handling the saw. Additionally, working without eye protection can increase the risk of eye injury from material debris thrown during beating or sawing. The use of this tool can also trigger musculoskeletal disorders if used repeatedly in an unergonomic posture.

The use of grinding machines (grinders) has a number of hazards and occupational safety risks (K3) that must be watched out for. Major risks include cuts or serious injuries from direct contact with fast-rotating grinding stones, as well as material debris that can be thrown during the grinding process, causing injuries to the eyes or skin. If the grinding machine is not properly controlled, the user is also at risk of losing control, which could result in injury to the hands or other limbs. In addition, exposure to dust generated from grinding metal or other materials can cause respiratory problems if adequate personal protective equipment (PPE) is not used. Noise from grinding machines also has the potential to cause hearing loss. It is important to use PPE, such as goggles, ear protection, gloves, and respirators, and to ensure that the machine is in good condition before use.

Sparks produced by grinders occur when the grinding stone rotates rapidly and comes into contact with metal surfaces or other hard materials. These sparks are the result of intense friction that melts small particles of metal and makes them burn due to the high temperature. Sparks can ignite flammable materials around the work area, such as fabric, paper, or flammable chemicals. Hot metal flakes from the fireworks can get into the worker's eyes, causing irritation, injury, or serious injury if eye protection is not used. If it comes into contact with the skin, hot particles from the fireworks can cause minor to moderate burns. The grinding machine that moves in a circular motion cuts off the body parts of the worker. Using a grinding machine that has been equipped with *Safety Guard* is absolutely dokuku. (Ihainen, 2019). "Every system *Safety Device* creating a statistically significant pattern of user dependency". The overall implication of this hypothesis is the recognition that people will shift their personal vigilance to dependence on *Safety Device* (Barnett, 2020).

3.2.4. Sources of Hazard from Working Methods

The lack of clear and structured work flows and procedures specific to formwork fabrication work is often caused by several key factors, including the complexity of the construction project, the

variability of the design, and the uniqueness of each project. Formwork is a temporary system that is built to hold concrete until it hardens and becomes a stable structure. Due to its temporary and flexible nature, formwork designs and techniques tend to be tailored to specific conditions in the field, such as the type of building, project location, and materials used. Additionally, industry standards for formwork fabrication refer more to general guidelines and best practices than highly detailed standards, as each project may require different solutions. The reliance on the expertise and experience of workers in the field also makes documentation of procedures often limited, with priority given to workplace adjustments rather than rigid rules.

3.2.5. Sources of Hazard from the Work Environment

a. Vibration

Vibrations in the machine can increase with the hardness and depth of the object being cut. The rougher, harder and deeper the object being cut, the greater the vibration of the machine will be. Not only that, but low engine power will also magnify the vibration (Şahinoğlu & Rafighi, 2020). The vibration display adjusts to the machine used. For machines such as grinders, they are limited to exposing the arms and hands. Exposure to exceeding the threshold value (NAV) that occurs during working hours is what then causes *Carpal Tunel Syndrome* (CTS). For this reason, paying attention to the NAV of vibration exposure is a must. NAV of vibration exposure to arms and hands is 5 m/s² for 8 hours of work (Permenkes Number 50 of 2017, 2017).

b. Noise

The activated grinder will create a sound from the operation process of the machine. The sound will increase when there is friction between the rotating grinding plate and the object being cut, resulting in noise. NAV noise is 85 db for 8 hours/day working duration (Permenaker RI Number 5 of 2018, 2018).

c. Hot Temperature

Extreme heat exposure poses a significant occupational hazard with life and death issues for workers working in outdoor environments for long hours. *Heat edema, heat cramps, heat syncope, heat exhaustion* and *Heat stroke* is a set of risks that can occur due to excessive exposure to outdoor heat (Sabrin et al., 2021). In construction work, seeing workers exposed to heat is commonplace.

d. Wood Dust

Wood dust resulting from cutting, sanding, or sawing activities, as is often the case with formwork workers, can pose a variety of health risks. Long-term exposure to wood dust can cause respiratory disorders such as bronchitis, asthma, or even chronic obstructive pulmonary disease (COPD). Some types of wood dust are also known to be carcinogenic, increasing the risk of nose and upper respiratory tract cancer. Additionally, wood dust can cause irritation to the eyes and skin, especially if exposed in large amounts without adequate protection such as masks or eye protection (HSE (Health and Safety Executive), 2020)

e. Fecal coliform

Fecal coliform is a group of bacteria that is often used as an indicator of fecal contamination in the aquatic environment. These bacteria come from human and animal feces, and their presence in water can indicate the presence of contamination and associated health risks. Fecal coliforms are generally composed of Escherichia coli bacteria (E. coli) found in human and animal feces. Exposure to fecal coliform can cause gastrointestinal infections, such as diarrhea, vomiting, and other symptoms associated with illness caused by contaminated drinking water (Kelly et al., 2021). The standard quality for fecal coliform in dry soil is a maximum of 5 grams (Permenkes Number 70 of 2016, 2016).

f. Mosquitoes and Centipedes

Mosquitoes and centipedes are arthropods whose existence must be monitored daily by workers because bites from both can cause disease. Malaria is a life-threatening disease caused by the Plasmodium parasite that is transmitted to humans through the bite of an infected Anopheles mosquito. There are five types of parasites that infect humans: P. falciparum, P. vivax, P. ovale, P. malariae, and P. knowlesi. Of these, P. falciparum and P. vivax are the most common, and P. falciparum is the most hazardous, with the highest rates

of complications and mortality (del Prado et al., 2014). Some types of malaria are tropical malaria, tertiana, quartana, and ovale malaria (Sroyer et al., 2022). Malaria is an acute febrile disease. In non-immune individuals, symptoms appear seven days or more (usually between 10 and 15 days) after an infective mosquito bite. The first symptoms – fever, headache, chills, and vomiting – may be mild and difficult to recognise as malaria. If left untreated within 24 hours, P. falciparum malaria can develop into a severe disease, often leading to death (WHO, 2023). Construction workers are vulnerable to a variety of health hazards. They often settle on land that is not suitable for settlement and are therefore very susceptible to malaria and other vector infectious diseases. Anopheles stephensi, the main vector of malaria, prefers to breed in wells, overhead and ground level ater tanks, fountains, rock tanks and water curing on construction sites (Shivalli et al., 2016). A highly conducive environment, the presence of agents and vectors, and unprotected construction workers form the perfect epidemiological triad for malaria. The highest morbidity at construction sites is caused by acute fever due to suffering from malaria (Adsul et al., 2011).

g. Workstation Layout

The mismatch of the layout of the workstation with the workflow is a condition in which the physical arrangement of equipment, machines, or work areas in a production or operational process is not in harmony with the flow of activities carried out by workers. This can lead to various problems in productivity, efficiency, and occupational safety. Here are some of the impacts of workstation layout misalignment with workflow, including wasted time and energy as workers have to move farther or frequently back and forth between workstations, resulting in wasted time and energy. It can also slow down the overall production process. Next, there is a decrease in productivity due to inefficient workflows, the time it takes to complete a single task or process becomes longer. This can reduce the productivity and output of the company. Furthermore, work errors and accidents due to workers who have to move between poorly organized workstations have the potential to experience confusion or stress, which increases the risk of work errors and accidents. Worker fatigue because workers have to perform unnecessary movements or activities, such as walking too far or lifting weights at suboptimal distances. This can lead to faster physical fatigue. Then there is an inefficiency in the use of space. An inappropriate layout can make the use of space inefficient. Certain areas may be overcrowded, while others are not used optimally. Next, collaboration disruption. If workstations for departments or individuals that need to collaborate are placed too far apart from each other, this can hinder communication and coordination, negatively impacting workflow and deliverables (Muther, 2014).

h. Awkward posture

The cause of awkward posture is usually related to factors that force the body to work in an unnatural or unergonomic position. Some of the main causes of awkward posture include: Unergonomic Workplace Design: The position of tools, tables, or equipment that is not adjusted to the height and posture of workers can force them to work in uncomfortable positions, such as bending over, reaching, or sitting for too long. Repetitive Tasks: Jobs that require the same body movements or positions continuously without pauses or variations, such as lifting objects or rotating the body repeatedly, can lead to awkward posture. Work in Tight or Confined Spaces: Narrow working conditions, for example under a desk or in other tight spaces, make workers have to take uncomfortable positions, such as bending or curling. Improper Work Habits: Lack of knowledge or training on good work techniques, such as how to lift weights correctly, can lead workers to adopt awkward postures, such as bending too far when lifting heavy weights. Inadequate Equipment: Unsuitable work tools, such as chairs or desks that cannot be adjusted in height, or manual tools that are less ergonomic, make workers have to adapt to unnatural postures. Physical Condition or Fatigue: Workers who are tired or have certain physical conditions may find it easier to take inappropriate postures due to reduced body consciousness or limited mobility.

i. Manual Heandling Activities

Risk factors that can increase the likelihood of injury in manual handling include: Heavy Loads or Unergonomic Shapes: Items that are too heavy, bulky, or difficult to handle can add stress to the body. Improper Posture: Lifting or moving weights with awkward posture, such as bending or twisting, increases the risk of injury. Frequency and Duration: Repetition

of manual handling movements for long periods of time without rest can result in muscle fatigue. Environmental Conditions: Slippery, narrow, or uneven floor surfaces can make manual handling more difficult and hazardous. Skills and Training: Lack of knowledge of safe manual handling techniques, such as how to lift weights correctly (using the legs and keeping the back straight), also increases the risk of injury

j. Repetitive Movements

Unergonomic Job Design, work processes designed with tasks that require workers to perform the same movements continuously, such as on a production or assembly line, result in repetitive movements. Production Needs or Targets: In some jobs, such as manufacturing or customer service, there are high productivity targets, so workers have to perform certain tasks repeatedly to reach quotas. Lack of Job Variety: If a worker's task has no variation or pauses, the worker is likely to perform the same movements without any change in body position or type of activity. Non-Compliant Technology or Tools: Tools or technology that are not ergonomically designed can force workers to perform unnatural or repetitive movements to operate the equipment. Jobs in Static Environments: Some jobs, such as typing or using precision equipment, require workers to stay in a certain position while performing the same movements over and over again, without much change in posture or movement.

4. Conclusion

Unsafe action is a potential hazard that originates from humans. The use of materials that are large, heavy and have sharp edges is a potential hazard that comes from production materials. The use of hammers, saws, rotation of grinding blades, sparks, use of improper Electrical connectors are potential hazards sourced from tools and machines. Working without a structured flow and procedure is a potential hazard that comes from the working method. Vibration, noise, heat pressure, dust, fecal coliform, mosquitoes, centipedes, unstructured workstation layouts, awkward postures, manual handling, and repetitive body movements are all potential hazards sourced from the work environment.

Each potential hazard has its own risk that has not been assessed in this study. Likewise, the determinants of its control have not been included in this study. For this reason, further research is needed to assess risks and determine control determinants based on the potential hazards that have been identified in this study.

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