

Potential hazards and risk identification of safety and health in iron fabrication area of building construction project

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ABSTRACT

Background: Hazard is a threat to the safety and health of workers. Iron fabrication as an iron work area to cut, bend, and assemble irons which will be used for building construction structures is not an exception for hazards. Preliminary observation has shown a number of hazards which were interesting to be identified further. This study aims to identify hazards in an iron fabrication area. It might be used as a basis to evaluate risks and decide appropriate control determinants.

Method: The type of this study was a descriptive survey with an observational approach. The method applied in the study was a Walkthrough Survey using hazard identification sheets as the instruments. Hazard identification was conducted based on UURI Nomor 1 Tahun 1970 (RI Law, 1970) and PPRI Nomor 50 Tahun 2012 (RI Government Regulation, 2012), i.e. by identifying hazards coming from humans, production materials, tools, machinery, work methods, and work environment.

Results: Unsafe action; Corroded iron coated with silica; Use of pliers, bending machine, cutting machine, grinder; Repetitive movements of manual handling, awkward body postures; Vibration, noise, heat pressure, dust, fecal coliform, mosquitos, centipedes, and scattered iron cuttings were some of the identified hazards.

Conclusion: Every hazard has its own risk whose extent has not been evaluated in this study. In addition, control determinants have not been elaborated. Therefore, further studies are required to evaluate the risks and decide the control determinants based on the hazards which have been identified in this study.



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1. Introduction

Every work place, either mobile or stand standing, above ground or underground, above water or underwater, even in the air, must have hazard which may bring the risk to harm, injure, hurt, even

kill the workers in it (RI Law, 1970). Hence, it may be meant that hazard is a threat to workers' safety and health.

"Hazard" is defined as the condition of humans, production materials, tools, machinery, work methods, work environment, workload, and work duration which has the potential to cause disturbance, damage, loss, accident, fire, explosion, pollution, and work-related diseases (RI Government Regulation, 2012; Wong et al., 2019; Leka & Jain, 2010).

Iron fabrication is an iron work area to cut, bend, and assemble irons which will be used for building construction structures in an ongoing project. There were 8-10 workers in the area who worked from 08.00 to 17.00 with a break time from 12.00 to 13.00. This means that the workers in the iron fabrication worked for 8 hours per day plus 1 hour break.

The results of preliminary observation revealed the presence of hazards in the iron fabrication such as scattered iron cuttings, use of cutting machine, repetitive movements, awkward body postures, and direct exposure to sunlight. These have attracted the researchers to carry out further identification hazards existing at the iron fabrication in the construction project of Gedung Unika by PT Adhi Persada Gedung.

2. Method

The research was carried out at the iron fabrication area of the construction project of Gedung IPC Unika Semarang by PT Adhi Persada Gedung. This was a descriptive survey study using an observational approach. The method applied was Walkthrough Survey using hazard identification sheets as the instruments. Hazard identification was conducted based on UURI Nomor 1 Tahun 1970 (RI Law, 1970) and PPRI Nomor 50 Tahun 2012 (RI Government Regulation, 2012), i.e. by identifying hazards coming from humans, production materials, tools, machinery, work methods, and work environment. This study aimed to identify hazards in an iron fabrication area. This study might be used as a basis to evaluate risks and decide appropriate control determinants.

3. Results and Discussion

3.1. Results

3.1.1. Identification of Hazards Coming from Humans

Table 1. Identification of Hazards from Humans

Work Area	Hazard Source	Hazard Description	Risk
Iron Fabrication	Humans	Unsafe action: Workers do not wear appropriate helmet	Anytime helmet may fall off the head Head being hit
		Iron bending operator wears knitted gloves	Knit threads of the glove may get stuck especially on deformed iron bars so that this would cause obstruction for the operator to lift hands after put the bars on the bending machine. Get pinched by bending machine
		Worker does not wear mask	Inhalation of dust from iron cuttings

Hazards coming from humans which had been identified were unsafe actions. The first unsafe action was workers' failure in wearing appropriate helmets. The risk which might happen anytime was the helmet falling off the head so that no protection is in place when a head bump happens. The second unsafe action was an operator of a bending machine wearing fiber gloves. The potential risk was that the glove fibers get stuck especially on deformed iron bars which could obstruct the operator in lifting the hand after putting iron bars on the bending machine. The third hazard was the workers' failure in wearing masks. The potential risk was the inhalation of dust from iron cutting.

*3.1.2. Identification of Hazards Sourced from Production Materials***Table 2.** Identification of Hazards Sourced from Production Materials

Work Area	Hazard Source	Hazard Description	Risks
Iron Fabrication	Production Materials	Production materials identified were plain iron bars, deformed iron bars, and rebar tie wire to make building structure. These iron materials were corrosive	Suffering from silicosis from silica content in the iron Getting punctured and scratched by iron bars and rebar tie wires which end up in suffering from tetanus

Hazard from production materials which had been identified were the use of plain iron, deformed iron, and rebar tie wires to make building structures. The possible risks were suffering from silicosis from silica content in the iron and getting punctured or scratched by iron and rebar tie wires.

*3.1.3. Identification of Hazards from Tools and Machinery***Table 3.** Identification of Hazards from Tools and Machinery

Work Area	Hazard Source	Hazard Description	Risks
Iron Fabrication	Tool	Use of tie wire pliers	Fingers getting pinched by pliers
	Machinery	Use of bending machine, cutting machine, and grinding machine	Hand getting pinched Hand getting cut CTS due to vibration

Hazards identified from tool and machinery sources were the use of and the use of bending machine, cutting machine, and grinding machine. The possible risks were fingers and hands getting pinched or cut.

*3.1.4. Identification of Hazards from Work Methods***Table 4.** Identification of Hazards from Work Methods

Work Area	Hazard Source	Hazard Description	Risks
Iron Fabrication	Work Method	Movement of pulling, lifting, lowering, and assembling irons done in manual and repetitive manners.	Respiratory fatigue Work-Related Musculoskeletal Disorders (WMSDs)
		Body postures of standing, bending over (bowing), and squatting during work	Work-Related Musculoskeletal Disorders (WMSDs)

The first hazards sourced from work methods which had been identified were the movements of pulling, lifting, lowering, and assembling irons done in manual and repetitive manners. The risks were respiratory fatigue and Work-Related Musculoskeletal Disorders. The second ones were the body postures of standing, bending over (bowing), and squatting during work. The risk was Musculoskeletal Disorders.

3.1.5. Identification of Hazards Sourced from Work Environment

Table 5. Identification of Hazards sourced from Work Environment

Work Area	Hazard Source	Hazard Description	Risk
Iron Fabrication	Work Environment	<p>a. Physical Factors: Vibration from grinding machine Noise from grinding machine Heat from sunlight >26°C</p> <p>b. Chemical Factors: Sand and soil dust Silica dust from irons</p> <p>c. Biological Factors <i>Fecal coliform</i> in dry soil Mosquitos Centipedes</p> <p>d. Work Area Scattered iron cuttings</p>	<p><i>Carpal Tunnel Syndrome</i> (CTS) caused by vibration Hearing disorder caused by noise Heat edema, heat cramps, heat syncope, heat exhaustion and heat stroke caused by exposure to excessive heat Dust being inhaled, swallowed, and absorbed resulting in the risk of suffering from pneumokoniosis such as silicosis, asbestosis etc. Diarrhea, intestinal inflammation, urinary tract infection, and gallbladder infection caused by <i>fecal coliform</i> Malaria and dengue fever caused by mosquito bites Infection caused by centipedes bites Getting stumbled, punctured, and scratched by scattered iron cuttings</p>

Hazards sourced from the work environment consisted of physical, chemical, biological, and area factors. The first hazards identified from physical factors were vibration and noise from grinding machines. The possible risks were *Carpal Tunnel Syndrome* (CTS) caused by vibration and hearing disorders caused by noise. Sunlight temperature of >26°C brought the risks of heat edema, heat cramps, heat syncope, heat exhaustion and heat stroke. The second were hazards identified from chemical factors, i.e. sand and soil dust and silica dust from irons. The risks were inhalation, swallowing, and absorption of the dust resulting in the risk of suffering from pneumoconiosis such as silicosis, asbestosis etc. The third were hazards identified from biological factors, i.e. presence of *Fecal coliform* in dry soil which brought the risks of diarrhea, intestinal inflammation, urinary tract infection, and gallbladder infection, presence of mosquitos with the risks of malaria and dengue fever, and presence of centipedes with the risk of infection caused their bites. The fourth were hazards from the work area due to the presence of scattered iron cuttings which brought the risks of getting stumbled, punctured, or scratched.

3.2. Discussion

3.2.1. Human Resources

In the construction industry, around 80-90% of accidents are caused by workers' unsafe actions. Hence, behavioral management plays a crucial role in improving safety. Specifically, behavior observation is the most important element to modify workers' behaviors in a safe manner (Hung & Su, 2021). Using helmets when working in highly hazardous workplace such as construction sector area is an absolute compulsory measure. The use of helmets should comply with the prevailing standards of SNI ISO 3873:2012 (BSN Indonesia, 2012). Helmet conditions should be inspected every time. Detecting workers who do not wear helmets could be done using the YOLO (You Only Look Once) technology which is processed using *Convolutional Neural Network* (CNN) (Mailoa & Santoso, 2022). Additionally, the use of gloves should be in accordance to the type and nature of

work. Referring to ANSI/ISEA 105-2016 and EN388, knitted gloves are not suitable for application in construction works (ANSI, 2016; EN, 2019). If the work involves gripping of hard, solid, and textured materials, then it is recommended to wear gloves made of cotton layered with composite rubber (Zhao et al., 2021).

3.2.2. Hazards from Production Materials

Heavy metal is defined as traced element with high density of at least five times of water density, detected widespread inside indoor spaces and building environment. Some examples of heavy metals are dust of iron, lead, and cadmium (Sabouhi et al., 2020). Exposure of lung cells A549 to ferric oxide nanoparticles coated with silica (Fe₃O₄@SiO₂-SH) may result in severe disorder of actin microfilaments and cytoskeleton microtubules and reduce the size of focal adhesion (Královec et al., 2020). Up to now, the use of irons for the structure of story building construction cannot be eliminated or substituted so that the risk of exposure to silica dust keeps on occurring.

3.2.3. Hazards from Tools and Machinery

The use of manually-operated tools and the use of machineries which move in vertical, horizontal, or circular (rotating) directions presents hazards to the workers who operate them. Getting pinched and getting cut of body parts the risks which may occur from the interaction with tools and moving machines.

Tie wire pliers are usually used to cut wires as needed. The cut wires are to be used to tie arranged structure irons. In this procedure, usually the left hand of a worker will hold the imperfectly tied wires to keep the wires in stable condition, then the right hand will do the job by turning the wires to lock the arranged irons tightly. The problem is that the left hand is not moved when the wires are turned with the pliers. This is the condition where the hand is in a risk of being pinched by the pliers.

An iron bending and iron cutting machine is operated with safety device system in the form of a pedal. When being stepped-on, the pedal will turn on the machine, and when being let-off the machine will stop. Various literatures have proven that the safety device system can minimize accidents (Contento et al., 2011). On the other hand, a hypothesis mentions that "Every safety device system would cause operators' dependence pattern which is statistically significant". The whole implication of this hypothesis is an acknowledgement that people would shift their personal awareness to their dependency on the safety device (Barnett, 2020).

Putting irons to be bent or cut on a bending and cutting machine is done in manual manners directly using hands. Usually, after the irons are put, their placement will be made neat using hands. This is the occasion where risks of being pinched or cut become high. A rotating grinding machine brings the risk of cutting body parts of the operator (worker). Using a grinding machine which is equipped with the safety guard is a must-to-do procedure (Ihainen, 2019).

3.2.4. Hazards from Work Methods

Pulling, lifting, lowering, and assembling movements which are done in manual and repetitive manners as well as standing, bending over, and squatting body postures during work are hazards that bring the risks of *Work-related Musculoskeletal Disorders* (WMSDs) (Korhan & Memon, 2019). In fact, the use of *occupational exoskeleton* by workers may minimize the risk of WMSDs (Theurel & Desbrosses, 2019). However, no reference is available to show that construction workers in Indonesia have used this equipment except the Indonesian National Army (TNI) (Salama et al., 2020).

3.2.5. Hazards from Work Environment

Vibration

Machine vibration may increase along with increasing level of hardness and thickness of the cut object. The rougher, harder, and thicker object would result in greater vibration. Besides that, low power of a machine will also increase vibration (Sahinoğlu, Rafeghi, 2020). Exposure to vibration depends on the machine being operated. For such a machine as grinder, the exposure will be limited to the arm and hand. Excessive exposure above threshold value would cause *Carpal Tunnel Syndrome* (CTS). Therefore, it is a must to pay attention to the threshold value of vibration exposure.

The threshold value for vibration exposure of arms and hands is 5 meter/second² for the duration of 8 hours (Kemenkes, 2017).

Noise

A running grinder will generate sound from the process of machine operation. The sound will increase in the occurrence of friction between the rotating grinding blade and the object of cutting in such a way that noise is generated. Noise threshold value is 85 db for duration of 8 hours/day (Kemennaker, 2018).

High Temperature

Extreme exposure to heat may result in significant work hazard with life-and-death issues for workers who work outdoors for hours. *Heat edema, heat cramps, heat syncope, heat exhaustion* and *heat stroke* are a collection of risks which may occur due to excessive exposure to heat outdoors (Sabrin et al., 2021). In construction works, it is common to find workers being exposed to heat.

Silica Dust

Crystal silica in the form of dust is present frequently in construction sites due to activities of concrete mixing, iron cutting, drilling, blasting, demolition, and pressure cleaning. Inhaling crystal silica may cause silicosis and increase the risk of lung cancer and other auto-immune diseases. Construction workers are also occasionally exposed to asbestos which is related to development of lung cancer and pleura, asbestosis, mesothelioma pleura and peritoneal, larynx cancer, ovarium, colorectal, pharynx, and stomach, benign lesi pleura, colon cancer, esophagus cancer, pancreas cancer, kidney cancer, and mesothelioma. Asbestos exposure may take place during installation of insulation, demolition, and renovation of buildings. However, it has been found that increase in the risk of lung cancers among masons is caused more by the exposure to crystal silica than the exposure to asbestos in construction area (Silva et al., 2019).

Fecal coliform

Fecal coliform is a group (colony) of bacteria which is frequently used as an indicator for fecal pollution in water environment. The bacteria come from human and animal feces. Their presence in water can indicate the presence of pollution and related health risks. Fecal coliform generally consists of *Escherichia coli* (*E. coli*) bacteria found in human and animal feces. Exposure to coliform may result in infection of digestive tract such as diarrhea, vomiting, and other symptoms related to the diseases caused by consumption of contaminated water (Kelly et al., 2020). The quality standard for fecal coliform in dry soil is 5 gr at the maximum (Kemenkes, 2016).

Mosquitos and Centipedes

Mosquitos and centipedes are arthropodes whose presence should be monitored on a daily basis by workers since their bites may cause diseases. Malaria is a life-threatening disease which is caused by *Plasmodium* parasites transmitted to humans through the bites of infected *Anopheles* mosquitos. There are five kinds of parasite that infect humans: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*. Among these five, *P. falciparum* and *P. vivax* are the most common, and *P. falciparum* is the most dangerous with the highest level of complication and fatality (del Prado et al., 2014). Several types of malaria are tropica, tertiana, quartana, and ovale malarias (Sroyer et al., 2022). Malaria is an acute fever disease. In a non-resistant individual, the symptoms appear within seven days or longer (normally between 10 and 15 days) after the mosquito bite. The first symptoms - fever, headache, shiver, and vomit - might be light and hardly identified as a malaria. If it is not medically treated within 24 hours, *P. falciparum* malaria may develop into severe disease, which frequently results in fatality (WHO, 2023). Construction workers are susceptible to various health risks. They often stay in areas not suitable for settlement and consequently are susceptible to malaria and other vector infectious diseases. *Anopheles stephensi* mosquitos, the main vector of malaria, prefer reproducing themselves in wells, overhead and ground level water tanks, fountains, stone tank, and curing water in construction sites (Shivalli et al., 2016). Highly condusive environment, presence of agents and vectors, and unprotected construction workers develop perfect triad of epidemiology for malaria. Highest morbidity in construction sites is caused by acute fever disease as a result of the suffering from malaria (Adsul et al., 2015).

Scattered Iron Cuttings

Object scattering in a workplace is intensely related to the principles of 5S safety culture. Implementation of 5S in a workplace would result in personal hygiene and workplace sanitation. 5S consists of five principles. The first is Seiri (simplicity) which is the sorting between necessary and unnecessary items. This means that only necessary items are kept in the workplace while the unnecessary ones are put away from the workplace. The second is Seiton (neatness) which is defined as the activity to arrange items such as deciding the layout, grouping of items, as well as the ruling of taking the items and putting them back upon usage. This would minimize searching time since this activity is affected by storage layout. The third is Seiso (cleanliness) which is defined as the activity to clean and inspect the feasibility of items. The fourth is Sheiketsu (maintaining) which is reinforcing or maintaining the previous 3 behaviours to be applied consistently. The fifth is Shitsuke (diligence) which is defined as making the 5S as habits in a workplace (Soltaninejad et al., 2022; Restipuri & Wahyudin, 2019).

4. Conclusion

Unsafe action is a hazard coming from humans. Iron which is corrosive in nature and contains silica is a hazard sourced from production materials. Use of tie wire pliers, bending and cutting machines, and grinders is a hazard coming from tools and machinery. Manual handling movement and awkward body postures are hazards coming from work methods. Vibration, noise, heat pressure, dust, fecal coliform, mosquitos, centipedes, and scattered iron cuttings are hazards sourced from work environment.

Every hazard bears its own risk whose risk levels have not been evaluated in this study. Additionally, their control determinant has not been elaborated either. Therefore, further study is required to evaluate the risks and to decide the control determinants based on the hazards already identified in this study.

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