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An investigation of fall accident in a high-rise building project

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Abstract. Fall accident is an accident category that becomes a primary cause of fatal and nonfatal injuries among construction workers worldwide. The objectives of the paper are to report the results of a study investigating 100 reports of fall accidents in the high-rise building project in Indonesia. The study concludes that the impact/consequence of the fall accident mostly occurring involves a fatality, causing death (56%), major injuries, causing permanent physical defect (28%), and minor injuries, causing temporary wound (16%). The main factors of fall accidents causation are mostly related to personal factors (61%) and non-personal factors (30%). It was found that fall accidents mainly take place in the area of scaffoldings (52%), area of structure (28%), and area of working structure (20%). The fall accidents occurred mostly during afternoon time (42%), followed morning time (27%), and evening time (21%), and workers who are 20 – 30 years old and under 20 years old get a higher risk of getting accidents. The findings will be a recommendation to construction companies for developing effective safety programs for the prevention of fall accidents.

1. Introduction

The need for infrastructure plays an important role in the development of the construction industry that directly contributes to economic growth. Statistic analysis in several countries concludes that the risk of occupational accidents in the construction industry is significantly higher if compared to the average of all sectors. In developing countries, the number of accidents in the construction industry is much worse [1]. In the construction project, fall accident is the major sources of accidents resulting in fatalities [2]. According to NBS [3], fall accident cases in China are still the highest type of accidents compared to other types of accidents. In Hongkong, 47% of fatal accidents happened due to fall accidents [4]. In America (1996 – 2006), fall accidents in building projects reached 32% of accidents that commonly ended with death [5]. According to Chi and Wu [6] concluded the fall accident from the high-rise building projects is the most serious accidents that happened in Indonesia. In Taiwan, more than 30% of accidents in building projects are fall. Sixty-nine percent of fall were from buildings project happened in New Zealand [7]. Larsson and Field [8] explored the perceived probability of serious accidents on the construction project. The result showed that “falling from a height” was considered most risky (92%). Besides the impact of accident fall, in addition to the reduction in the quality of life of construction workers and the loss of life, construction incidents lead to project delays. Fall accident is the most costly occupational hazard in many countries. Accidents affect increased project costs due to direct costs and indirect costs [9]. The direct effect maybe billions of dollars annually [1,3], and indirect costs of incidents are estimated to be six times more than the direct costs.

According to the number of accidents and the consequences of the fall, accidents should be a



priority to prevent. Comprehensive knowledge about the causes of an accident it is important to determine prevention strategies [1,2]. A system of accident investigation reports is one of the tools used to investigate the factors that cause accidents. This report is based on direct evidence that the accident was reported immediately after the accident occurred on site. A complete reporting system consists of a chronology of an event, a reporting mechanism, which makes the procedure reports and submission of reports to the responsible party. The content of the report is to report directly on the existing condition of the event include the time of the accident occur, workplace condition, weather, the direct cause of the accident, and the victim's condition after the accident [1,3]. The report is a priority to be analyzed further to determine the factors that direct cause of the accident for accident preventive.

The theory of the accident causality on construction projects continues to be developed to complement the theory with different types of data sources, methods, and analyses of different approaches [1,2,6]. Unfortunately, the previous theories are not enough to describe the nature related to the accident occurred or accurately estimate the possible causes for the accident to happen [1,7].

2. Literature review

2.1. Accident construction in Indonesia

In the last decade, the construction industry in Indonesia increases dramatically. However, at the same time, its work safe is worse. The data from PT. Jamsostek shows a serious accident in Indonesia. Figure 1 shows an accident number in Indonesia from 2010 to 2017. The data PT Jamsostek suppose is only about 50% of the actual numbers, because the data is taken from the number of claims reported to Social Security. While only approximately 50% of contracting companies that insure their workers to Social Security and the lack of desire of companies to report accidents that occur in the company [8]. The number of accidents in construction projects in Indonesia is higher than in other industries. Table 1 shows accidents in the construction sector accounts for almost 32% of all accidents in all sectors followed by manufacturing and transportation sector.

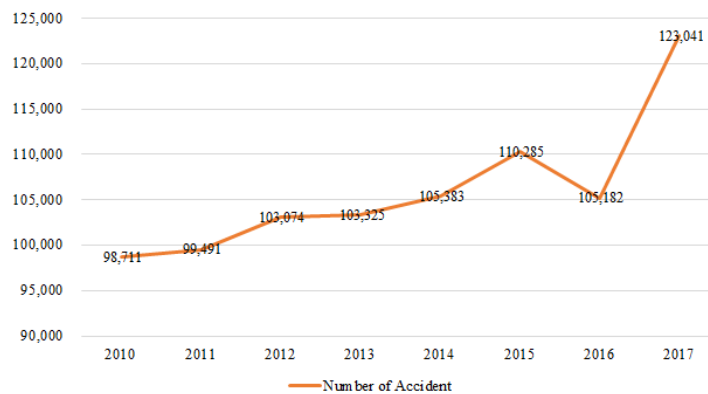


Figure 1. Number of an accident in Indonesia

Table 1. Comparison of the accident in the construction industry and others

Sector	Accident rate
Mining	2.6%
Forestry	3.8%
Transporation	9.3%
Construction	32%
Industry	31.6%
Other	21.3%
Total	100%

Safety issues drew little attention from stakeholders from Indonesia. The level of awareness of workers to work safely is lacking, and this is due cause by their low education. More than 50% of 4.5

million workers studied up to elementary school only, daily workers, and lack of awareness of the company to implement a safety program [2,5]. They conclude construction accidents in Indonesia are mostly led by human factors, equipment, and environment. The awareness of APD application and work safely behavior is still low due to the low safety culture. Another problem is that the government regulation on K3 has not been sufficient to solve the accident phenomenon, and the implementation of it in a construction project is still low [5,9].

2.2. Theory of accident causation construction in Indonesia

The construction industry is a series of activities based on the engineering system, which is unique and special for each activity. Zou et al. [3] stated that the construction industry is planning, designing, constructing, operating, and maintaining activity that transforms materials into physical infrastructures. Furthermore, Chan et al. [4] gave more emphasis on construction project-produced products and stated that construction is a physical infrastructure creation resulting in roads, bridges, harbors, and other products such as schools, buildings, and homes. Both of them defined construction in a slightly different way from Wells by giving more emphasis on its process. The industry is viewed as a process of physical construction to create infrastructures such as roads, bridges, irrigation systems, and buildings contributing to social development.

The construction industry is always vulnerable to accident, in which the high-rise building project is one of the construction projects in the construction process which is complex and requires coordination from various types of skill and technology; a difficult situation, a complex activity, and most of its activities are carried out in altitude. Work-related falls from heights remain a significant problem for workers in construction projects [7,8]. Based on the factors resulting in a fall accident in a construction project, the theories can be classified into two general parts, which are:

- Individual accident
The approach is supported by theories stating that human errors are the main factor leading to the accident. Some theories, including The Accident Proneness Theory, The Goals-Freedom-Alertness Theory, The Adjustment-Stress Theory, The Distraction Theory, discuss the causes of the individual accident.
- Organizational accident
The approach is supported by theories concluding that accidents can be led by multi factors, including human that is internal factors, and non-personal factors involving failed management, organization, and bad work field, etc. Therefore, the approach emphasizes that human is not a basic factor, or it is not the only factor resulting in the accident. Some theories supporting the organization approach include The Domino Theory, The Constraint-Response Theory, and The Multi-Factor Theory.
- The nature of fall accident
An Accident can be defined as something unplanned, uncontrollable, and unwanted, which disrupt the formal functions of a person or persons and causes injury or near-miss or an unplanned, uncontrollable event that can cause or generate injuries on workers, damage on types of equipment and other loss.

An accident fall is defined as an event in which a person was coming to rest unintentionally on the ground or other lower level, not by the result of a major intrinsic event such as (stroke) or overwhelming hazard. Fall accident consists of 2 types, which are (i) falling from a height, for example: fall from groundwork, fall from a ladder, slipped from a ladder. (ii) Fall from elevation, for example, falling by slipping, tripped, or fall to the ground or floor/lower level. It concludes its type categorizes the kinds of fall accident on building, that is: (i) fall from elevation; (ii) fall from platform; (iii) fall from ladder; (iv) fall from piled matter; (v) fall from stairs; (vi) fall into openings; (vii) fall from roof; (viii) fall to lower level.

The factors causing occupational work was influenced by extrinsic factors or latent factors, which consist of design factors, organization factors, and environmental factors [4,6,9]. The vulnerability of construction in the process leading to falling is caused by five factors including human factors, equipment factors, organization factors, management factors, and environmental factors [7]. Human

factor are aspects that can be observed through some of the conditions from human behaviors that can trigger the vulnerability causes of fall accidents such as lack of awareness of the use of PPE and methods, poor safety conscientiousness of workers, low education level of workers, lack the experience of workers, overtime and lack of health and physical characteristics of workers [8]. Equipment factor includes a vulnerable equipment condition such as lack of safety equipment specifications, lack of inspection and maintenance on equipment and no permit operation of the equipment [9]. Organization factors are factors that describe the conditions that led to a vulnerability to the accident falls such as lack of organizational commitment and lack of strict regulatory penalties and no/low reward. Management factors are factors that describe the conditions that led to a vulnerability to the accident falls such as low/no safety program and standard, lack of strict operational procedures and planning, poor standards of safety contracts, less/no supervision and monitoring safety, less /no budget safety and less/no safety communication. Environment factor is factors that describe the conditions that led to a vulnerability to the accident falls such as poor working surfaces and platforms, lack of lighting systems and severe weather.

3. Research methodology

This study complements the results of previous studies with different approaches to analyzing the factors that cause fall accidents from evident data. The data are 100 of 368 accident investigation reports fall in building construction projects in PT Jasmotek from 2010 to 2015, taken randomly. This report was a fall accident case investigation records by PT. Jasmotek. The Indonesian government appoints as a work-safe insurance agent. Report as part of the documents in the event of a claim. The study did a further analysis to find out the nature of the accident that includes: (i) resulted from impacts/consequences; (ii) main factors of the fall accident; (iii) time of the accident occurrence; (iv) ongoing works during fall accident; (v) fall accident location; (vi) victim's age.

The result of the study is a recommendation to the contractor as stakeholders directly involved in construction projects to determine prevention strategies should be implemented for the prevention of fall accidents in construction projects. As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

4. Results and discussion

According to data analysis of 100 fall accident investigation reports using statistical analysis, it is resulted that impact/consequence of the fall accident mostly occurring involves fatality, causing death (56%), major injuries, causing permanent physical defect (28%), and minor injuries, causing temporary wound (16%). It explains that fall accident remains the main fatal injuries cause in construction projects.

The main factors of fall accidents causation are mostly related to personal factors (61%) and non-personal factors (30%), as shown in Table. 2 below. Personal factor remains the main factor of a fall accident. The PPE usage is still low due to workers' poor awareness of work safe. PPE can be uncomfortable, can decrease work performance and can create new health and safety hazard. Some workers, for instance, refuse to wear the earmuffs because it makes them feel hot, especially in hot regions.

Intensive socialization program safety is a priority for workers to increase awareness of the use of PPE, and training programs to improve their knowledge and skills are required for workers. In addition to safety, oversight is needed at the site, on the other hand, the company's management committee is also required to prepare a personal protection program, safety penalties and safety awards to workers who perform/no PPE program.

Fall accidents may occur in many places in the high rise building projects. It was found that the fall accidents mainly take place in the area of scaffoldings (52 %), area of structure (28%) and area of working structure (20%). Figure 3 below shows the shreds of evidence of where the fall accidents usually take place. The poor housekeeping, a broken ladder, or a structurally deficient work platform are unsafe condition sites that vulnerable to lead fall accidents. The impact of factors leading to the falling accident is shown in table 2.

Table 2. The impact of factors leading to a falling accident

Impact/consequence	Number of accident cases	Percentage (%)
Fatality	56	56%
Major Injuries	28	28%
Minor Injuries	16	16%
Near miss	0	0%
Total accident	100	100%

To improve the performance of safety-relevant to an effective safety program. One safety program was required safety inspection on equipment such as scaffolding and ladders. Inspection equipment includes safe equipment specifications, provision of safety equipment that the most effective in improving the performance of safety equipment. Otherwise, fall accidents, according to the working area, are shown in table 3.

Table 3. Fall accident according to the working area

Working Area	Percentage
Scaffolding	56%
Ladder	20%
Structure	24%
Total	100%

Fall accidents may occur at a different time off during working hours. In this case, the data analysis was based on the number of accidents occurring every hour for a whole day or 24 hours since many building projects in Indonesia are working for a whole day. Table 3 shows that the fall accidents occurred mostly during afternoon time (42%), followed morning time (27%), and evening time (21%). The afternoon time is the time on which workers are working under fatigue and less concentration due to many potential distractions. To pursue productivity construction, project management pushes workers to work more (work overload), as shown in table 4. The management pressure to increase productivity may result in the workers developing high stress that trigger accidents.

Table 4. The fall accident occurred

Working time	Number of cases	Percentage (%)
Morning zone (08.00 - 12.00 am)	27	27
Break time zone 12.00 - 13.00 pm	1	1
Afternoon zone 13.00 - 17.00 pm	42	42
Evening zone 17.00 - 24.00 pm	21	21
Undetected	9	9
Total accident cases	100	100

Fall accidents also occurred in many types of the working process. It was found that fall accidents mainly related to workers when working for structural framework work (21.9780 %) and finishing works (17.8713 %), as shown in figure 4. Scaffolding and ladder work ladder is a category of work that has high hazardous trades in building construction projects. Program supervision and inspection of the workplace to be an important, job analysis, safety training programs for a framework to be a top priority for workers. The type of works that probably has a huge chance of the accidental condition is shown in table 5.

Table 5. Type of works occur fall accident

Working Area	Percentage
Material preparation and Demolition work	56%
Structural formwork	21.97%
Scaffolding work	12.98%
Working on the ladders	14.28%
Lifting works	1.09%
Structural works	15.38%
Supervision works	3.29%
Finishing works	17.87%
Total	100%

Fall accidents may occur to any age of workers working in the construction industry. Figure 5 shows workers who are 20 – 30 years old and under 20 years old get a higher risk of getting accidents. Hu (2011) concluded that underage quite results in a fall accident during work. It is very related to the young workers, having no experience of working in construction project behavior, as shown in table 6.

Table 6. The age of accident fall

Workers' age	Percentage
Material preparation and Demolition work	56%
Structural formwork	21.97%
Scaffolding work	12.98%
Working on the ladders	14.28%
Lifting works	1.09%
Structural works	15.38%
Supervision works	3.29%
Finishing works	17.87%
Total	100%

The result of the analysis of the study of the implementation of the safety policy concluded that the highest level of implementation of the occupational safety program is the implementation of a safety program on foreign private contractor companies. They are based on the discussion of the results obtained, then to see the best practice of the implementation of safety programs conducted studies on projects undertaken by foreign contractor companies that have been surveyed.

5. Conclusions

In this paper, the nature of fall accidents in high-rise building projects construction in Indonesia is presented. Fall accident is the main cause of fatality (58%) in the construction project. The human factor (61%) becomes the direct factor frequently resulting in a fall accident. The findings will be recommendations to the contracting companies for developing effective safety programs for the prevention of fall accident is to improve the competence and skill of workers at altitude through formal training which has been appointed by government agency, so that the workers have a recognized license in carrying out work at altitude Punishment for workers who do not wear personal protective equipment properly, for example, fined or not allowed to work in the project environment.

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