

Study Of The Causal Factors Of Construction Projects Vulnerability To Accidents

Rosmariani Arifuddin, Akhmad Suraji, Yusuf Latief

Abstract: *Statistical data in several countries shows that workplace accidents in construction industry are very high compared to other industries. Building construction projects are sites that are vulnerable to workplace accidents so that efforts to prevent accidents sets to a top priority. To recommend an effective accidents prevention strategy, comprehensive knowledge of the factors causing work accidents is needed in construction projects.*

The objectives of the study are: (i) identify the vulnerability factors of the construction project to work accidents; and (ii) further analyze the level of vulnerability of the factors causing the vulnerability of construction projects to accidents in construction projects.

This research is a comprehensive study through the study of work accident reports in construction projects from PT Jamsostek as well as perceptual surveys through questionnaires distributed to workers from construction projects using the sampling method.

The results of the study indicate that the factors causing the vulnerability of construction projects to workplace accidents are determined by 5 main factors which are: i) human factor, ii) equipment factor, iii) organizational factor, iv) management factor and v) environmental factor. The results of the analysis further explains that environmental factors are the highest factor followed by equipment factors and organizational factors, human factors and management factors. The dominant sub-factor causing the vulnerability of construction projects is "Unsafe workplace conditions" is the highest sub-factor (DoV = 8.3827), followed by a sub-factor "Equipment specifications not compliant with safety standards" (DoV=8.3467). The next sub-factor is "Lack of organizational commitment to safety" (DoV = 8.3356), "Unsafe action from workers" (DoV = 8.3145), "Unsafe conditions of workplace" (DoV = 8.3125), Lack of worker awareness to safety (DoV value of 7.3064).

Index Terms: *Causal Factors, Construction Project, Vulnerability and Accident.*

I. INTRODUCTION

The construction industry plays a strategic role in a country's current economic growth. This is indicated by the contribution of the construction industry to the relatively large Gross Domestic Product (GDP) [1]-[2]. However, in some countries, the construction sector still has problems with regard to Safety, Health and Environment.

Statistical data from several countries show that the rate of accidents in the construction industry is much higher than in

other industries [3]. Moreover, in developing countries, the number of workplace accidents is much worse than in developed countries [4].

Accidents have a significant negative impact on many aspects. At the enterprise level, work-related accidents have the effect of reducing the company's reputation [5] and financial losses resulting from direct costs [6] and indirect costs, estimated to be six times higher than direct costs [7]. At the project level, work-related accidents cause delays in the completion of the project due to lost work hours and an equally important impact is to reduce the quality of human life such as injuries, partial disability or fatality [8].

Occupational accidents in the construction sector continue to record the worst records compared to other sectors in several countries. In Hong Kong, accidents at construction sites are the highest fatal accident rate of 47% [9]. In China, the proportion of accidents at work is the highest at 51% [10] and data from the China Statistical Yearbook [3] confirms occupational accidents by 48% [11]. Workplace accidents in the United States between 1992 and 2006 were the highest, at 32% [12]. In Spain that the accident-related death rate decreased by 40% [13].

The New Zealand Department of Labor (2010) noted that the highest rates of workplace accidents were in the construction sector [14]. Chi & Hung (2004) reported that more than 30% of deaths in construction projects in Taiwan were due to falling work accidents [15].

In Indonesia, referring to data in [16], which indicated that the construction sector accounted for the highest number of work-related accidents, with 32%, with 6,266 workplace accidents or more than 2,000 cases per year (PT Jamsostek, 2011).

The high rate of accidents in construction projects indicates that these are still high risk sites or are still highly vulnerable to workplace accidents [17]. This shows the need for accident prevention efforts to be a priority. Accident prevention strategies are integral to improving safety in construction projects. Recommending a strategy to prevent workplace accidents in the event of a fall requires a thorough knowledge of the factors that contribute to workplace accidents [14]. Therefore, based on the phenomenon of the cause of accidents at work, it is concluded that knowledge of the accident causation theory is a key word to determine the strategic effort of prevention of accidents at work on construction projects.

This research was developed to learn more about the underlying causes of the vulnerability of construction projects to work-related accidents by identifying the causes, structure and level of contribution to workplace accident vulnerability in construction

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projects. Research axes on high rise building projects. In addition, the discussion in the study on the underlying factors of the causes of occupational accidents has been contextualised as conditions likely to cause accidents at work in construction projects. Understanding the mechanism of cause mechanisms and the dynamics vulnerability of construction projects to accidents is very important in identifying the root causes and the behavioral factors leading to occupational accidents during the operational period in order to recommend effective workplace accident prevention strategies in construction projects.

The objectives of the research are: (i) identify the vulnerability factors of the construction project to accidents; and (ii) further analyze the level of vulnerability of the factors causing the vulnerability of construction projects to accidents in construction projects.

II. LITERATURE REVIEW

The definition of an accident at work is an unplanned event that disrupts a person's normal functioning that could lead to injury or death in the workplace [18]. As in [19] emphasizes the definition of occupational accidents in construction projects, which not only human impacts, but also damage to project ownership and the project environment.

Safety is always associated with the release condition of near misses. Although workplace safety in construction projects is specifically a means of maintaining safety for a person who builds, operates, maintains and destroys engineering works and who may affect it. Safety in the construction industry has broader dimensions, namely worker safety, public safety, property safety and environmental safety, which require a systemic, integrated and comprehensive approach to the safety of workers. general aspects of the socio-engineering of organizations implementing upstream and downstream construction [20].

Improving safety in construction projects has been achieved through different approaches, one of which is the application of workplace safety policies. To minimize the risk of accidents, it is necessary to develop safety rules and apply them strictly [21].

The theory of accident causality in general has been developed with different perspectives and approaches, including: (i) the scope of the factors causing occupational accidents, (ii) the structure of the factors causing occupational accidents, and (iii) the linkage mechanism. with the causes of work accidents. The theory of causes of occupational accidents begins with a theory based on factors related to the behavior and actions of unsafe individuals or workers (unsafe acts) as the main factors causing occupational accidents [22]. In addition, it should be noted that, in addition to human factors, work-related accidents can also be caused by work-related factors, such as the condition of work systems that do not comply with safety standards at work, the lack of inspection procedures for work instrument and work instrument that does not comply with safety standards [23].

The phenomenon of the causes of accidents is also linked to organizational factors, such as the lack of commitment on the part of organizations for safety [24], the lack of culture safety in insecure organizations [25] and not the existence of a sanction system or compliance with the implementation of safety [26]. The causes of work-related accidents can also be identified by management factors, including the lack of safety policy both at the company level and at the site [27], as well as environmental factors including the effects of bad weather and hazardous work environments [14]-[23].

The theory of causes of occupational accidents is developed to study the structure and mechanism of interaction of the factors. The pattern of occupational accidents causes immediate causes of work-related accidents and contributory causes. The structure of the factors causing accidents at work can also be identified from their orientation, namely the factors causing upstream occupational accidents and the causes prior to the downstream exploitation [20].

Based on the perspective of the mechanism of the cause of occupational accidents, the mechanism of interaction of the factors responsible for occupational accidents experiences a paradigm shift, from the interaction of linear to non-linear mechanisms. Understanding the mechanism of linear causes is the description of the causes of work-related accident events with a chain of events that interact sequentially [28]. While the nonlinear mechanism is a description of the mechanism of the relationship between the causes of multifactorial work-related accidents and a chain of complex events [29].

III. RESEARCH METHODOLOGY

The focus of the study is the need for in-depth knowledge of the factors that make construction projects vulnerable to accidents, as a basis for determining policy strategies for effective fall prevention. The stages of the research are presented in the Figure 2

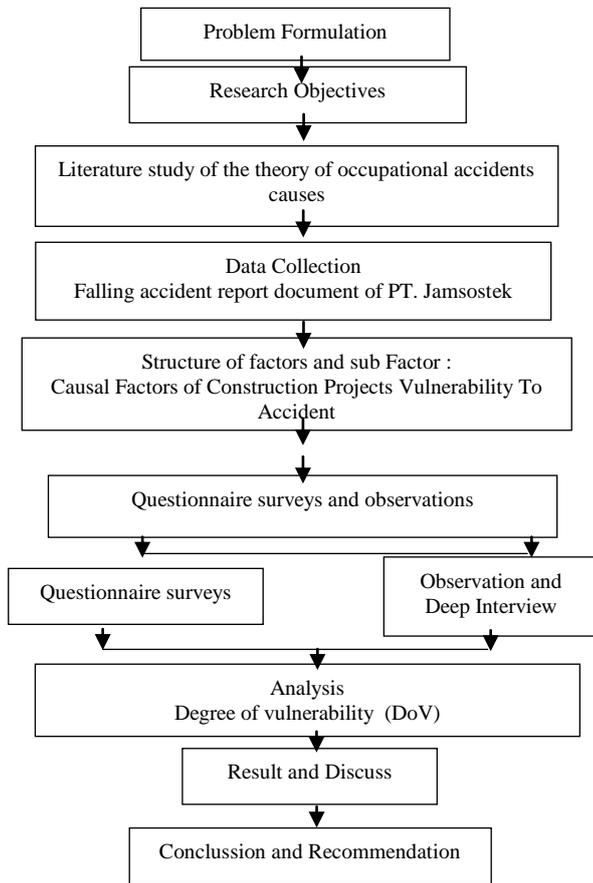


Figure 2. Research Phases

The research begins by identifying vulnerability factors to accident projects. The next step is to identify and analyze the vulnerability factors obtained by conducting a questionnaire survey to determine the value of its contribution, referred to as the level of vulnerability of DoV (Degree of Vulnerability). DoV (Degree of Vulnerability) is a large number that indicates the level of vulnerability of work accidents in construction projects. The values of DoV are obtained from the formulation of the risk level of each factor with the following equation:

$$DoV = Probability \times Impact \tag{1}$$

- Probability (P) is the value of the possibility of occurrence of these factors, including: 1 = rarely; 2 = medium; 3 = frequent.
- Impact (I) is a value indicating the impact or consequence that will occur if there is a vulnerability factor in the construction project, including: 1 = minor ; 2 = medium; and 3 = major

Tabel 1. Degree of Vulnerability (DoV)

P/I	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9

DoV 1 - 3: Low Vulnerability
DoV 4 - 6: Moderate Vulnerability
DoV 7 - 9: High Vulnerability

The structure of the factors causing the vulnerability of construction projects to work-related injuries is obtained by mapping 350 reports of workplace accidents in construction projects from 2014 to 2016. Accident reports on construction projects are selected by sampling method. In addition, this report is complemented by related literature reviews. At the same time, to determine the value of the virtual value, the data were collected through questionnaire surveys and observations involving 50 respondents, ie workers from 5 building construction projects in the DKI Jakarta region. . In addition, the questionnaire data were further analyzed by statistical analysis to determine the ranking value of each factor and the variable ranging from the causes of vulnerability of construction projects to accidental falls.

1. Result and Discuss

The results of PT Jamsostek's work accident report mapping show that the factors that make construction projects vulnerable to accidents can be grouped into 5 main factors, namely: i) human factors, ii) factors related to instrument, iii) organizational factors, iv) management factors and v) environmental factors, as shown in Figure 4.

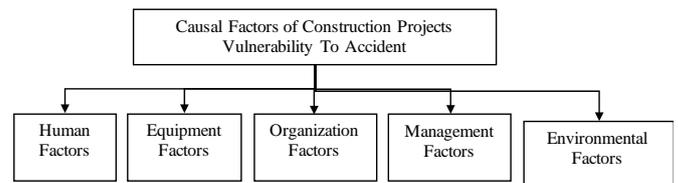


Figure 4. Factors and Sub Factors of Causal Factors of Construction Project Vulnerability to Accident

In addition, based on the analysis of the data, the sub-factors of the 5 main factors are presented in Table 2.

Table 2. Factors and Sub-Factors of Causal Factors of Construction Project Vulnerability to Accident

Num	Factors and Sub-Factors	Reference Source
Human Factors		
1	Unsafe action from from workers	[21]-[30]-[31]-[32]
2	Lack of worker awareness to work safety	[21]-[33]-[27]
3	Inappropriate age of the worker	[21]-[14]
4	Lack of work experience	[21]-[31]-[32]-[34]
5	Lack of education and skills of workers	[21]-[31]-[32]-[33]



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Num	Factors and Sub-Factors	Reference Source
6	Unstable emotional condition	[21]-[12]-[22]
7	Work under the influence of alcohol or illegal drugs	[21]-[33]-[35]
8	Fatigue works	[21]-[31]-[32]-[33]
9	Un authority at work	[21]-[22]-[36]
11	Poor physical and mental conditions from worker	[21]-[31]-[32]-[33]
12	Low economic status of workers	[14]
Equipment Factors		
13	Equipment specifications not compliant with safety standards	[21]-[12]-[14]-[37]
14	Lack maintenance and inspection of equipment	[21]-[30]-[31]-[32]
15	Unavailability of standard procedure regarding usage of the equipment	[21]-[30]-[31]-[32]
Organizational Factors		
14	Lack of safety culture in team work	[21]-[30]-[32]-[25]
15	Lack of a system of penalties and rewards for workers	[22]-[26]
16	Lack of organizational commitment to safety	[21]-[31]-[32]
Management Factors		
17	Lack of safety inspection	[21]-[31]-[32]
18	Ineffective operation/ lack of compliance to safety regulation	[21]-[30]-[31]-[32]
19	Lack of work safety programs	[21]-[31]-[32]-[38]
20	Lack of safety training	[21]-[30]-[31]
21	Lack of availability of safety resources/ PPE	[21]-[30]-[31]-[32] - [38]
22	Management pressure	[21]-[30]-[31]-[32] - [38]
23	Lack of safety contract	[21]-[30]-[31]-[32] - [38]
Environmental Factor		
24	Bad weather conditions (rain, wind and sunray)	[21]-[30]-[31]-[32] - [38]
25	Unsafe workplace conditions	[21]-[14]
26	Poor lighting and air circulation systems	[21]-[38]
27	Limited workplace	[21]-[30]-[31]-[32] - [38]

analyzed to obtain a possible level of Degree of Vulnerability obtained from the probability value and the impact caused by each factor, then ranked in **Table 3**.

Table 3. Rank of Factors and Sub-Factors of Causal Factors of Construction Project Vulnerability to Accident

Nu m	Sub Factors	Factors	DoV
1	Unsafe workplace conditions	Environmental Factors	8.3827
2	Equipment specifications not compliant with safety standards	Equipment Factors	8.3467
3	Lack of organizational commitment to safety	Organizational Factors	8.3375
4	Unsafe action from workers	Human Factors	8.3145
5	Unsafe conditions of workplace	Environmental Factors	8.3125
6	Lack of worker awareness to safety	Human Factors	7.3064
7	Bad weather conditions (rain, wind and sunray)	Environmental Factors	7.268
8	Inappropriate age of the worker	Human Factors	7.2417
9	Lack of work experience	Human Factors	7.2333
10	Limited workplace	Environmental Factors	7.223
11	The low index of knowledge and skills of workers	Human Factors	7.1750
12	Lack of safety inspection	Management Factors	7.1500
13	Lack of availability of safety resources/ PPE	Management Factors	7.1087
14	Poor physical and mental conditions from worker	Human Factors	7.0475
15	Lack maintenance and inspection of equipment	Equipment Factors	7.0431
16	Unavailability of standard procedure regarding usage of the equipment	Equipment Factors	7.0403
17	Ineffective operation/ lack of compliance to safety regulation	Management Factors	7.0305

In addition, the data from the questionnaire collection was

18	Lack of safety training	Management Factors	7.019
19	System conditions and physical damage to work equipment	Equipment Factors	7.0113
20	Management pressure	Management Factors	7.0107
21	Lack of safety culture in team work	Organizational Factors	7.0105
22	Lack of a system of penalties and rewards for workers	Organizational Factors	7.0100
23	Work methods not consider safety factors	Management Factors	7.0093
24	Unstable emotional condition	Human Factors	7.0069
25	Inappropriate age of workers	Human Factors	7.0031
26	Lack of Safety Manual	Management Factors	7.0025
27	Lack of Safety Contract	Management Factors	7.0018

Table 3. shows that all subfactors are at high values of vulnerability to vulnerability. The sub-factor " Unsafe workplace conditions" is the highest variable (DoV=8.3827), followed by the variable "Equipment specifications not compliant with safety standards" (DoV=8.3467), then "Lack of organizational commitment to safety", Unsafe action from workers (DoV=8.3145) and Unsafe conditions of workplace (DoV=8.3125), "Unsafe conditions of workplace" (DoV = 8.3125), Lack of worker awareness to safety (DoV value of 7.3064).

This can be explained by the fact that, on the basis of the DoP score of the factors and variables identified, environmental factors such as workplace safety are factors that strongly contribute to the spread of a project to work accidents in construction projects.

Workplace conditions and surface conditions remain the root causes of prevention accidents. Similarly, specifications or quality requirements for equipment or work aids used include scaffolding / platforms and ladders. The contractor often uses work equipment that does not conform to standard specifications to reduce the cost of the project in order to generate maximum profit. The impact that may be caused by the use of work equipment that does not meet the standards of safety at work causes an accident at work that may lead to a greater loss of the project.

IV. CONLUSSION

Based on the results and discussions from the research, it can conclude :

1. The main vulnerability factor for construction projects to accidents is determined by 5 factors: i) human factors, ii)

- instrumental factors, iii) organizational factors, iv) management factors and v) environmental factors.
2. The dominant level of the primary factor that makes the project vulnerable to accidents is environmental factors, then factors, instrumental factors, organizational factors and human factors.
3. The results of the analysis further explains that environmental factors are the highest factor followed by equipment factors and organizational factors, human factors and management factors. The dominant sub-factor causing the vulnerability of construction projects is " Unsafe workplace conditions " is the highest sub-factor (DoV = 8.3827), followed by a sub-factor "Equipment specifications not compliant with safety standards" (DoV=8.3467). The next sub-factor is " Lack of organizational commitment to safety " (DoV = 8.3356), "Unsafe action from workers" (DoV = 8.3145), "Unsafe conditions of workplace" (DoV = 8.3125), Lack of worker awareness to safety (DoV value of 7.3064).

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