A COMPARATIVE STUDY OF ACCIDENT RISK FACTORS IN CONSTRUCTION PROJECT IN INDONESIA

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Abstract

The construction industry is perceived to be one of more dangerous industries, which has a poor safety performance record globally. However, in developing countries, these difficulties and challenges present alongside a general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues. There is also evidence that the problems have become greater in extent and severity in recent years.

The objective of this paper is to report the results of a study conducted to analyze the risk level of a construction accident at a project. The study was carried out on the project undertaken by contractor company in Indonesia, consisting of 3 types of companies which are state-owned companies, private companies and foreign private companies. The risk level was assessed using a risk significance index based on the likelihood of occurrences and the impacts on accident.

The research method includes direct observation and questionnaire survey to highrise building projects. Direct observation is an instrument to measure likelihood level of accident risk accurance, and questionnaire survey, for respondents' perspectives gaining, is used to assess the consequence level of the accident at the project. The data were analyzed using Risk Matrix from *AS/NZS 4360:2004 Risk Management Standard.*

The result shows that in construction projects in Indonesia, accident risks at state companies and private companies are higher than those at foreign private companies. Factors which are mostly included in high risk accident category such as "lack of safety equipment specifications", poor working surfaces and platforms", "low education level of workers", "lack of organizational commitment", and "Low/no safety resource".

The current study contributes to government of Indonesia in term of suggestion in evaluating safety program enforcement in highrise building construction projects.

2

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1. INTRODUCTION

Statistic analysis in several countries concludes that risk of occupational accident in construction industry is significantly higher if compared to the average of all sectors (Kamardeen, 2009). The construction industries around the world offer substantial employment opportunities and contribute significantly to national economic growth, but a the sime time they have unacceptably high rates of injuries and fatalities (Zou 2009). In developing countries, the number of accidents in construction industry is much worse (Koehn, 1995). Construction sites exhibit unique hazardous features, such as crowded sites, operating at height and outdoors, unskilled labor and extensive use of heavy machines and equipment (Kamardeen and Theo, 2007; Ismail and Chik, 2008; Zou, 2009; Hu and Ramandad, 2009;).

The impacts of occupational accident are significant, involving not only death and workers' decreased quality of life, but also delay in project, increased project cost, medical expenses, and other negative consequences (Lipscomb et al., 2003). Financially, occupational accident effects on direct costs that reach million dollars per year, while indirect costs are estimated to be six times more than the direct costs (Gavious, et. al, 2009).

2. AN ACCIDENT CONSTRUCTION IN INDONESIA

In Indonesia, safety program in construction project has not attained much attention from all parties (Wirahadikusumah, 2005). Although for Indonesia's better reputation at safety field the Department of Labor and Transmigration of Indonesia has made policy to reduce the accident rate to 50%, Indonesia is still recorded as a country with highest rate of accident. The research of ILO (International Labor Organization) in 2009 reported that Indonesia was at 152 rank from 153 countries observed. It means that occupational accident is a bad problem in the country (http://www.nakestran.go.id).

The number of the accident in Indonesia was the highest in ASEAN region. There were almost 32% of the accident cases that occurred in construction sector involving all types of work project such as construction of road, bridge, tunnel, and dam (http://www.nakestran.go.id).

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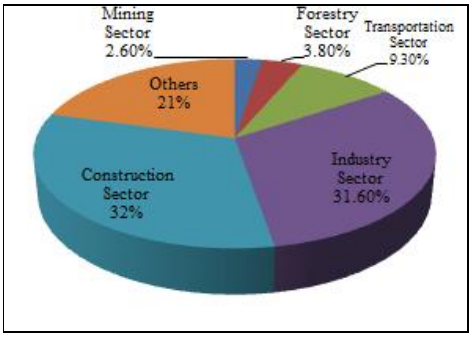

Figure 1. Comparison of accident in construction industry and others

Based on the data of Jamsostek, there were 6,266 cases of accident that occurred in construction industry in 2008-2010. Based on the data, the accident resulted in injury and fatality. The causes varies such as trap, hit, etc.

Table 1. Types of Accident Cases in Construction Industry in 2008-2010

Year	Cases					Total
	Cured	Disable Function	Partial Disable	Total Disable	Fatality	
2008	2,015	72	72	2	146	2,307
2009	1,787	59	77	3	143	2,069
2010	1,622	50	57	4	157	1,890
	5,424	181	206	9	446	6,266

Source : PT. Jamsostek, 2011

3. RISK OF CONSTRUCTION OCCUPATION ACCIDENT

Accident can be defined as unexpected, undesirable, and uncontrolled situation that can result in lost to humans, property and the environment (Suraji, 2000).

In construction project context, the accident of construction project is an accident which is related to work of workers working at construction projects; the accident includes accident that occurs on the way to workplace from home or vice versa (PT. Jamsostek).

Occupational accident is caused by the low ar the lack of safety program (Rowlinson, 2003). According to Davies and Tomasin (1990), safety is a hazard risk free, including physical injury and health damage risk for a period of time. Davies (1990) concluded that work safety in civil engineering context is a way to maintain the safety of someone who is building, operating, maintaining, devastate, and other technical works.

Hinze and Haslam in Kamardeen (2009), suggested occupational accident that frequently

occurs in construction project involved some types of accidents defined into eight categories.

(i) *Falling from height* - involves workers falling from higher floors to lower floors/ground level, and falling from ground level to excavation level

(ii) .*Struck by falling object/ moving vihicles* – primarily involves workers being struck by equipment, private vehicles, falling materials,vertically hoisted materials and horizontally transported materials,

(iii) *Excavation-related accident* – encompass cave-in, contact with underground utilities, subsidence of nearby structures, falling of materials/vehicles/objects on to people working in the excavation, fumes, gases, and inrushes of water at the bottom of excavations.

(iv) *Accident by operation of machinery/ tools* – caused by toppling of machinery, collapse of the parts of machinery, and unsuitable or unsafe hand-held tools.

(v) *Electrocution* – caused by contact with electric current from machines, appliances, light fixtures, faulty electrical equipment and tools, and contact with overhead/underground power lines.

(vi) *Fire/ explosion* – resulting from explosion of pressure vessels or gasoline pipes, and fire due to welding/hot works

(vii) *Failure of temporary structures* – involves the failure or form works and scaffoldings

(viii) Others – e.g. slipping on the same level, oxygen deficiency in confined spaces, lightning strike, etc.

Previously, a prior study on factors leading to occupational accident based on safety perspective has been done. Tam et al. (2004) concluded the risk-prone activities on construction sites, and highlighted factors effecting construction site safety. The study concluded that the commitment of contractors to safety were of grave concern, including lack of training, lack of certified skill labor, low education and lack of provision of personal protection equipment. Zou and Zhang (2009) conducted comparative study on the perception of construction safety risks in China and Australia. This study perception of safety risk factors included five issues which are legal and regulatory issues, education and training related issues, employee related issues, technical issues and organizational management related issues. The study results revealed that the main perception of safety risks of construction industry in China came from human and/or procedure related issues, with “low/no safety education” paramount, followed by “inadequate fire prevention and electrical prevention procedures,” etc. In contrast, the major safety risks perceived in Australia were related to the environment and physical site conditions with “contamination of land, water and air” ranked first, followed by “unforeseen excavation of soil,” etc. To minimize construction safety risks in China, this paper suggested that the government should develop collective legislation and safety protection procedures, and enforce safety education and training to all site participants. Risks related to

environmental and site conditions were generally realized by the Australia construction industry, which were not highly acknowledged in China. This may also bring imminent attention in this regard to the Chinese government.

A contractor company, as the main executor of the construction project, is required to enforce carry out the project safely. Based on the ownership, there are some kinds of construction companies in Indonesia. They are:

- **Private companies** are companies which capital is wholly owned by the private sectors and there is no government intervention. There are three kinds of private company, there are three kinds, namely :
  Private company, a private company owned by the State Indonesia ;
  Foreign private companies, a private company owned by foreign nationals, and
  Mixed private company (joint-venture), a private company owned by the state Indonesia and foreign nationals.
- **State companies** are companies which capital is wholly owned by the State Indonesia.

4. RESEARCH METHODOLOGY8

The research methodology selected for this risk investigation comprised a comprehensive literature review, a survey to construction company, a statistical analysis of the survey data, and exploration of safety risk management in Indonesia.

4.1 OBSERVATION SURVEY AND QUESTIONNAIRE DESIGN

The survey was conducted through observation and questionnaire. Observation is for direct investigation to highrise building construction projects. There were ten projects carried out by state-owned companies, ten projects by nationwide private companies, and 10 projects by foreign private companies chosen randomly. The observation was conducted to get level of likelihood of occurance accident risk factors. Whereas level of consequence was obtained through questionnaire survey. The survey involved three to four safety employees of each observed project sites. The survey was designed to assess the perspectives which respondents held on various construction company accident risk factors in Indonesia. Through literature reviews and understanding the problems, 21 questions reflecting accident risk factors were identified and classified into five aspects: six questions related to human issues, tree related to equipment issues, two related to organization issues, seven describing management issues, and the last tree questions related to environmental related issues.

4.2 DATA COLLECTION

A total of 120 questionnaires were sent to thirty project / construction sites selected. Respondents involved in the questionnaire are safety officers who work directly in the construction project. The construction projects in this study consists of three (3) types of companies are state-owned companies, private companies and foreign private companies. Comparison of projects and companies are shown in the Table 2.

Table 2 Comparison of Project and Contractor Company

`	State –owned companies	Private companies	Foreign private companies
Project Construction	10	9	2
Contractor company	6	5	2

Each project involved 2-4 respondents who are safety employees consisting of safety manager, safety officer, and safety inspection. From 102 responses received, 18 were invalid due to reason such as being incomplete, damaged, inappropriate.

There were 35 responses of state-owned companies, 30 responses of private companies, and 37 of foreign private companies.

Table 3 Comparison of Education Level of Respondents

Education Level `	State –owned companies	Private companies	Foreign private companies
Master or above	2 (5.71 %)	1 (3.33 %)	8 (21.62 %)
Undergraduate	5 (14.29 %)	6 (20.00 %)	25 (67.57 %)
High school	19 (54.29 %)	22 (73.33 %)	4 (10.81 %)
Junior high school	8(22.86 %)	0(0 %)	0(0 %)
Primary school	1 (2.86 %)	1 (3.33 %)	0(0 %)
Total	35 (100 %)	30 (100 %)	37 (100%)

In addition to the information of education level, there were information of workers' position level and working experience obtained through questionnaires (Table 3).

Table 4 Comparison of Position Level of Respondents

Position Level	State companies	Private company	Foreign private companies
Safety Manager	5	3	5
Safety Officer	23	6	16
Safety Inspection	7	21	16
Total	35	30	37

4.3 DATA ANALYSIS

The survey includes three groups of data the likelihood of occurrence of each risk and its level of consequences. The risk significant index developed by Zou and Zhang. (2009) was used. The four-point scales for the likelihood α (very likely, likely, unlikely, and highly unlikely) and the consequence (impact) β (fatality, major injury, minor injury, negligible injury) were converted into numerical scales. The matrix presented in Table 2 shows the converted numerical values and the calculation of the risk significance index.

Table 5. Construction Accident Risk Assessment Matrix
(Adapted from Zou and Zhang, 2009)

Consequence/ Impact	Likelihood			
	Very likely (0.9)	Likely (0.6)	Unlikely (0.3)	Highly likely (0.1)
Fatality (1.0)	0.90 (H)	0.60 (H)	0.30 (M)	0.10 (L)
Major injuries (0.7)	0.63 (H)	0.42 (M)	0.21 (M)	0.07 (L)
Minor injuries (0.3)	0.27 (M)	0.18 (M)	0.09 (L)	0.03 (L)
Negligible injuries (0.1)	0.09 (L)	0.06 (L)	0.03 (L)	0.01 (L)

Note H = high M = medium; and L = low

The significance score for each risk assessed by each respondent can be calculated through Eq. (1), which is similar to the one developed by Zou and Zhang (2009)

$$ri\,j = (\alpha ij \beta ij)/n \qquad (1)$$

Where r_{ij}=significance score assessed by respondent *j* for the impact of risk *i, i*=ordinal number of risk, *i* E (1 ,*m*); *m*=total number of risks; *j*=ordinal number of valid feedback to risk *i, j* E (1 ,*n*); *n*=total number of valid feedbacks to risk *i;* ^{a}ij =likelihood of occurrence of risk *i,* assessed by respondent *j;* and $I3_{ij}$=level of consequence of risk *i,* assessed by respondent *j*.

The average significance score for each risk can be calculated through Eq. (1). This average score is called the risk significance index score and can be used to rank among all risks where Ri^{k}= significance index score for risk *i.*

It should be noted that the method for calculating the risk significance index score may overlook the extreme risks with a very low level of likelihood of occurrence but a very high level of consequence, which should be taken into account in the risk management practice.

The likelihood of occurrence was indicated by the values from the lowest figure of 0.1 (where the safety risk would be highly unlikely to happen), to 0.3 (unlikely), to 0.6 (likely), to 0.9 a (representing very likely to be the most critical risk level). The consequence of the safety risks resulting in an injury was shown with similar but slightly adjusted figures, with 0.1 representing negligible injuries, 0.3 minor injuries, 0.7 major injuries, and 1.0 fatality. The reason for the slight difference where death is represented by a whole figure is because of the severity of the impact. According to AS/NZS 4360 (2004), the figures italicized in Table 3 represent high or major risk factors; the lowest value from the group of high risk factors is 0.27. Hence, only the safety risk factors with a significant index score of 0.27 and above are discussed in the following

5. FINDING AND DISCUSSION

The respondents' education background is summarized in Table 3. It shows the comparison of the level of education of the respondents in the three companies. It, furthermore, shows that more 50 % of safety employees in construction company have completed high school. The education level of foreign private companies is higher than of state and nationwide private companies. Besides, respondents from foreign private companies have more experience lengths in construction industry. They have an average of 12 years of experience, while those from state and nationwide private companies have 7 years of experience.

Table 5 shows the significant index score of construction accident risk factors in the three companies.

Table 6. Significant Index Score of Accident Risk Factors

Accident risk factors	Significant Index Score Construction projects undertaken		
	State companies	Private companies	Foreign private companies
Human/ Personal related issues			
Lack of awareness of the use of PPE and methods	0.58 (H)	0.54 (H)	0.12 (L)
Low education level of workers	0.62 (H)	0.59 (H)	0.40 (M)
Excessive overtime work for labor	0.56 (H)	0.62 (H)	0.12 (L)
Lack the experience of workers	0.51 (H)	0.60 (H)	0.10 (L)
Poor safety conscientiousness of workers	0.43 (M)	0.42 (M)	0.32 (M)
Lack of health and physical characteristics of workers	0.32 (M)	0.28 (M)	0.22 (M)
Equipment related issues			
Lack of safety equipment specifications	0.67 (H)	0.65 (H)	0.09 (L)
Lack of inspection and maintenance on equipment	0.56 (H)	0.50 (H)	0.09 (L)
Permit operation of the equipment	0.42 (M)	0.56 (H)	0.05 (L)
Organizational related issues			
Lack of organizational commitment	0.61 (H)	0.54 (H)	0.18 (M)
Lack of strict regulatory penalties and rewards	0.53 (H)	0.54 (H)	0.23 (M)
Management related issues			
Low/no safety training and education	0.52 (H)	0.54 (H)	0.02 (L)
Management Pressure	0.42 (M)	0.55 (H)	0.04 (L)
Low/no safety program and prosedure	0.41 (M)	0.42 (M)	0.14 (L)
Lack of strict operational procedures	0.35 (M)	0.39 (M)	0.14 (L)
Poor standards of safety contracts	0.29 (M)	0.42 (M)	0.16 (L)
Low/no safety resource	0,59 (H)	0,56 (H)	0,04 (L)
Less / no supervision and monitoring safety	0.43 (M)	0.56 (H)	0.08 (L)
Enviromental related issues			
Poor working surfaces and platforms	0.66 (H)	0.45 (H)	0.11 (L)
Severe Weather	0.62 (H)	0.58 (H)	0.40 (M)
Lack of lighting systems	0.41 (M)	0.34 (M)	0.10 (L)

Human related issues

The result from human related issues shows that human factors are aspects which need more attention in term of construction occupational accident prevention. The factors are significant for high risk accident. Of the factors issue, "low education level of workers, particularly, is ranked as the highest risk followed "lack of awareness of the use of PPE and methods", "excessive overtime work for labor" and "lack the experience of workers" for projects which were carried out by state companies and private companies. Meanwhile, for projects carried out by foreign private companies, issues of human factors are entirely categorized as medium risk accident and low risk accident.

Equipment related issues

Similar to human factors, the analysis of equipment factors shows that the factors are significant for high risk accident at projects which were carried out by state companies and private companies. The relevant issue of the factors such as "lack of safety equipment specifications" remains high risk accident issue. Whereas, the equipment factors are significant for low risk accident at projects which were held by foreign private companies.

Organizational related issues

The analysis shows that organizational factors are high risk accident in construction projects by state companies and private companies. The relevant issue like "lack of organizational commitment" at projects highly contributed to the accident risk at the projects by the companies. The rank is followed by "lack of strict regulatory penalties and rewards". For projects of foreign private companies, organizational factor are considered medium risk accident.

Management related issues

Compared to the other factors, management factors are considered relative lower risk accident in construction projects. For projects carried out by state companies, "management pressure" followed by "low/no safety training and education" issue is high risk accident. In addition to the issues, "less / no supervision and monitoring safety" is high risk accident in construction projects by private companies. Whereas, the factors are considered low risk accident for projects which were carried out by foreign private companies.

Environment related issues

Environment factors are significantly high risk accident at projects of state companies and private companies. The relevant issues involve "poor working surfaces and platforms" and 'Severe Weather". For projects carried out by foreign private companies, whereas, the factors are low risk accident.

6. CONCLUSION

Based on the analysis results, it is concluded that:

- In construction projects in Indonesia, accident risks at state companies and private companies are higher than those at foreign private companies. It suggests that the projects which were carried out by state companies and private companies are high risk accident.
- Factors which are mostly included in high risk accident category, both at state-owned companies and nationwide private companies, are equipment factors, followed by environment factors, human factors, and organizational factors. Whereas, management factors are considered medium risk accident. This reveals that the preceding factors become the priority of occupational accident prevention efforts. Whereas, human factors and organizational factors are medium risk accident, and environment factors, equipment factors and management factors are low risk accident for foreign private companies.
- The issues need to get priority in accident prevention in Indonesia construction projects include most of the factors such as “lack of safety equipment specifications”, poor working surfaces and platforms”, “low education level of workers”, “lack of organizational commitment”, and “Low/no safety resource”.

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