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PRELIMINARY STUDY ON THE IDENTIFICATION OF SAFETY RISKS FACTORS IN THE HIGH RISE BUILDING CONSTRUCTION

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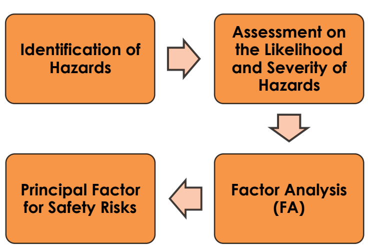
Graphical abstract



Abstract

The construction industry is one of the risky workplaces attributable to its complexity and dynamic nature of construction activities. High rise building construction remains predominant for high accident rates counted yearly. A site-specific assessment tool that considers the characteristics and changeable conditions of the currently managed construction site is necessary to precisely assess safety risks. Therefore, this study aims to address the significant safety risks and principal factors associated with the high rise building construction projects in Malaysia. Responses obtained within the construction management personnel are evaluated using factor analysis to understand the latent critical risk factors. Preliminary findings suggest that all safety risks are significant and working environment is identified as the most critical principal factor which consists of diverse underlying safety risks with high loading factors. Successful investigations of the study will lead to the development of a high rise building construction safety and health risk model. From the practical view, these findings should assist the high rise construction project participants to be more attentive to health and safety issues.

Keywords: Construction safety, high rise building construction, safety risk factor

1.0 INTRODUCTION

The continuous growth of economy promotes interaction relationship with construction industry. In response to economic development, construction industry at present took a new turn towards high rise construction encompasses hotels, commercial buildings, office complexes and high rise dwellings. The necessity of high rise construction mostly concentrated in many large cities coupled with central business attraction and dense population. A high rise structure varies between 75 feet and 100 feet or about seven to ten stories depending the slab to slab distance between floors [1].

Due to increasingly dynamic and complex lifecycle of a construction project, it is positioned as a dangerous or highly hazardous industry [2]. The nature of construction industry is derived from several fragmentations of the involved parties throughout the various phases of construction projects [3]. It requires harmonization of different interdependent contractors, sub-contractors and operations that may result in increased risk of injury [4]. Construction industry is recorded as the third leading cause of occupational accidents in Malaysia [5]. Statistics on occupational accidents revealed that high rise building construction is as one of the riskiest workplaces [6].

Construction risk management has distinctive attention among the practitioners and scholars. It is initialized from assessing the hazards and potential risks depending on the work activities and the site condition. Nevertheless, many scholars and practitioners recognized hazards in the construction industry as one; deficient attention was given to the explicit category of the construction project. A site-specific assessment tool that considers the characteristics and changeable conditions of the currently managed construction site is necessary to precisely assess risk. Therefore, this paper aims to address the safety risks and principal factors associated with the high rise building construction projects in Malaysia.

1.1 High Rise Building Construction Hazards

In essence, construction activities are allied with the variety of dormant hazards. High-rise buildings are the recent trend in construction industry because of its convenience, advantages, architectural design, grade and luxury. It is characterized by continual changes, use of many different resources, poor working conditions, no steady employment, tough environments such as noise, vibration, dust, handling of cargo and expose to stochastic elements such as weather conditions, soil characteristics and road accidents [3].

Many scholars categorized hazards into natural disaster such as bad weather or climate conditions and technological disaster like chemical spill and explosion [2, 7]. Construction project normally bound to a tight schedule, thus burden the workers with excessive workload [2]. This situation will induce psychological hazards ensuing in stress, loss of motivation and lack of intrinsic satisfaction.

The management team in a construction project acts as a role model to influence safe attitude among construction workers, thus nurturing safe environment. Several studies indicated that highly qualified industry professionals are proficient in accurately quantifying relative safety risks for specific tasks and work environments [8]. Given that, it is vital to have insight on the perceptions or previous experience of the construction management personnel on assessing the likelihood and severity of the hazards and safety risks.

1.2 Accidents Causation

Accidents are derived from arising hazards and risks in the construction project. Accident causes from machineries and tools always being a major percentage, but acute effect such as permanent disabilities or deaths are frequently happen in high rise building construction site for instance fall from height and vertical transportation of materials [9-11]. In high rise buildings, accidents mostly occur at temporary structures that the failure prone than the permanent structure because it is easily getting damaged due to frequent dismantle and reuse.

Accidents ensued in a great burden to employee and employer in terms of absenteeism, loss of productivity, ergonomic disabilities, high cost incurred, bad company reputation, higher incidence rates of illnesses and fatal [4,11]. Accident investigation findings concluded that accident causations are rooted from poor working condition, management failure, unsafe acts and non-human related events [5]. Human error such as improper lifting, contributed by unstable working surfaces and misuse of fall-protection equipment worsen the situation. Study by [7] stated that accident arises from failure in the interaction between construction personnel and workplace; whilst equipment and materials giving rise to the incident circumstances.

1.3 Risk Evaluation

Risk is present in all project components of any projects irrespective of their size or sector. It is a measurable uncertainty because the same hazard does not always present the same risk. Safety professionals are the anchor person at the construction site who needs to conduct a comprehensive risk assessment to improve safety performance at the site [12-14]. Various approaches in risk characterization have been proposed in many literatures to prioritize the risk management strategy. Chapman [15] for instance grouped risks into environment, industry, client and subject while Shen *et al*. [16] categorized the risks into financial, market, legal, management, policy and political. On the other hand, Zou *et al*. [17] grouped risks according to project objectives comprised of cost, time, quality, environmental and safety. This research intends to identify safety risks pertaining to the principal factors.

2.0 RESEARCH METHODOLOGY

The research methodology employed is qualitative and quantitative data collection through site visits, key project personnel interview and electronic mail questionnaire. The hazards scenarios were sourced from a wide range of related literature. It is believed that the selected 30 hazards listed in the survey are comprehensive to represent significant risks that might occur in the high rise building construction project.

2.1 Sample Composition

A total of 21 questionnaires are collected representing a preliminary stage of the research. The respondents were construction personnel in the high-rise building construction projects. The respondents' working experience, the organization they represent and job title in the project involved deduced that the respondents' have good knowledge on the hazards and risks pertaining to high rise building construction project. The details of the organization and respondents' profile are summarized in Table 1.

Table 1 Profile of organization and respondents

Characteristics	Number (N)	Percentage (%)
Organisation		
Public sector	3	14.3
Private sector	18	85.7
Organisation's role		
Contractor	11	52.4
Developer	5	23.8
Client	1	4.80
Consultant	4	19.0
Job title		
Safety and health officer	3	14.3
Site engineer	4	19.0
Project engineer	4	19.0
Safety supervisor	5	23.8
Site supervisor	5	23.8
Years of experience		
Less than 5 years	10	47.6
5 to less than 10 years	5	23.8
10 to less than 15 years	2	9.5
15 to less than 20 years	1	4.8
More than 20 years	3	14.3

Utmost percentage of the respondents works in the private sector because it is common in Malaysia where high rise building construction projects are dominated by private companies. Majority of the high rise projects involved in this study comprise of commercial lots, office buildings and high rise residential such as luxury condominium. Explicitly, eleven of the organizations are contractors, five are developers and the rests are clients or consultants.

In terms of respondents, safety and site supervisor accounted for the highest professional roles among the respondents. While eight of them are engineers and the remaining are safety and health officers. A total of 38.% of the respondents work as safety and health personnel which shows that they have very good knowledge pertaining to construction safety. On top of that, 52.4% of the respondents are experienced construction personnel with more than five years of working experience in construction industry. These results demonstrate the reliability and quality of the data.

2.2 Factor Analysis

Factor analysis is the statistical approach involves finding a way of condensing the information contained in a number of original variables into a smaller set of dimension. Zainudin [18] states that for established item, the factor loading should be 0.6 or higher. High factor loadings indicate critical factors and variables [19]. In the factor analysis procedure, items which compose similar characteristic was grouped together under one component and summarized using a smaller set of factors or components [20-22]. The selected name for the principal factors should be brief and denote the nature of the underlying construct.

3.0 RESULTS AND DISCUSSION

Table 2 shows the factor loading for all 29 safety risks under five principal factors namely working environment, exposure to hazardous condition, work at high elevation, inadequate safety protection and temporary structures. From the analysis, factor loading for 29 items are 0.6 and higher which indicates significant result. Meanwhile only one item is excluded from the analysis due factor loading less than 0.6.

3.1 Principal factor 1: Working environment

Working environment factors comprise the largest number of safety risks with 12 underlying items. The results indicate that combination of challenging construction environment and work activities are statistically significant. The main factor loading is hot weather and strenuous work (0.867). Malaysia is a tropical country with hot and humid weather throughout the year. It is inevitable that extreme temperature together with long working hours cause tiredness of workers besides workload demands and supervisor pressure [23]. Good working environment will stimulate workers to work effectively and in a safe condition. Hollnagel [24] asserted that working conditions, time of the day and operational support as influencing factors to safety at the construction site.

3.2 Principal factor 2: Hazardous condition

Highest loadings in this factor are chemical explosion or reactions (0.901) and working with or being near to flammable materials (0.885). These two factors record for the highest factor loadings among all items due to the severe and catastrophe effect. Lower loadings are made of exposure to the hazardous atmosphere in confined space (0.639) because most of the projects do not construct confined space. Acute exposure to the hazardous condition can cause detrimental health effects and property damage.

Table 2 Factor loading for safety risks according to its principal factor

Safety risks	Factor loading	Ranking
Principal factor 1 : Working environment		
Hot weather and strenuous work	0.867	1
Ladder propped against a wall	0.836	2
Emotional stress, fear and anxiety	0.822	3
Strong wind when work at height	0.814	4
Exposed electric wires	0.802	5
Damaged electrical extension cord	0.780	6
Excessive noise from equipment and machineries	0.738	7
Dust from soil, stone or concrete	0.727	8
Work with loose materials at height	0.723	9
Heavy objects fall from a tall stack of materials	0.648	10
Inadequate site lighting and ventilation	0.641	11
Work with facade elements on a scaffold at height	0.636	12
Principal factor 2 : Hazardous condition		
Chemical explosion or reactions	0.901	1
Working with or being near to flammables materials	0.885	2
Limited or delayed accessibility to the upper floor	0.844	3
Containers of corrosive materials	0.770	4
Exposure to hazardous atmosphere in confined space	0.639	5
Principal factor 3 : Work at high elevation		
Structural collapse	0.821	1
Fall from height	0.757	2
Improper safety-net system	0.735	3
Failure to secure heavy materials during lifting	0.705	4
Principal factor 4 : Inadequate safety protection		
Unprotected outside edge of a slab or balcony	0.812	1
Moving construction equipment and machineries	0.775	2
Exposed sharp edge of a reinforcing bar or mesh	0.650	3
Fixed scaffold without adequate fall protection	0.645	4
Unprotected shaft or hole	0.602	5
Principal factor 5 : Temporary structures		
Missing platform on a scaffold	0.834	1
Improper installation of formwork	0.788	2
Inappropriate plank installation	0.785	3

3.3 Principle factor 3: Work at high elevation

This factor contains four underlying items. The highest factor loading is given to structural collapse with 0.821. This reflects the importance of strong structure and foundation in high-rise building construction. Besides, fall from height and improper safety-net system has closed loading factors with 0.757 and 0.735 respectively. Numerous literatures found that fall from height and objects fall from height are among the predominant accident cases in high rise building construction [9-11]. This analysis suggests that sufficient peripheral netting is very crucial to ensure no chance of objects falling off the perimeter of building.

3.4 Principle factor 4: Inadequate safety protection

Principal factor 4 consists of five underlying items with high factor loading. The highest factor loading is the unprotected outside edge of a slab or balcony with 0.812 while the lowest loading is unprotected shaft or hole (0.602). Inadequate protection for risky work activities at site contributes to unsafe condition which prone to accidents. Thus, top management commitment towards safety should be improved by providing adequate time for supervision, budget allocation and motivation to the workers.

3.5 Principle factor 5: Temporary structures

Temporary structures entail three underlying items. Missing platform on a scaffold (0.834) ranks for the utmost factor loading while the lowest factor loadings are improper installation of formwork and inappropriate plank installation. In a construction industry, installation of temporary structures needs good technical competency of the workers. It is due to the changing work activities that need the workers to fix or secure, dismantle and reuse temporary structures for several times. The important of technical competencies and capabilities by the project team leader also highlighted by [25]. Technical competencies are the demonstrated abilities and skills that should include the constructability of a project in the design and the understanding on the design process [26].

4.0 CONCLUSION

The analysis results successfully discriminate the latent risk factors through risk evaluation. Despite assessing the significant safety risk is deemed crucial, identification of the latent factors is equally important. This paper has presented the identification of principal factors to understand the underlying items of the critical safety risks. Further research can apply this method to formulate an effective safety and health risk model for the high rise building construction project.

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