Factors Affecting Safety Performance of Construction Projects: A Literature Review

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Abstract. The construction industry is known as the most hazardous industry and has always been plagued with accident for a long time. Incidents or accidents that happened at construction sites has caused several drawbacks of project performance, such as delay in project completion, increase project cost, reduce productivity and create negative impressions to the organization. Therefore, it is crucial for employer to ensure safety and health at the workplace is taken care of to avoid accident. This paper presents the review of the factors affecting safety performance of construction project, focusing on project level. Among the most frequently cited factors that affect safety performance of construction project in project level are safety training, implementation of safe working environment and implementation of safe plant and equipment. The outcomes of the paper may serve as a starting point for further research in investigating the main.

1. Introduction
In many countries in the world, the construction industry plays a big role for development process which contributes towards the economic growth that generating additional demands for construction activities. Despite its significant contribution towards economic growth of the country, construction industry has also contributed to large fatality rates due to high number of accidents [1]. Construction workers who involved directly in construction activities faced a greater risk of fatality compared to the workers in other industries, as proven by accident statistics [2]. In Malaysia, the Department of Occupational Safety and Health (DOSH) [3] revealed that the highest number of occupational accidents by sector in 2017 is in construction industry, with 15 deaths from out of 70 (as in May 2017). Several studies have revealed that, there has been rapid growth in the number of accidents related to occupational safety and health, which cause injury and even death during the last five years [4-6].

Major construction projects in Malaysia are exposed to dangerous conditions which can cause accidents and consequently affect the safety performance of the construction projects. The causes of accidents in construction industry are related to unique nature of the industry, human behavior, improper site conditions, unsafe work method, equipment and procedures which affected from poor safety management [7]. These causes could result in accidents which further cause disruption of work and decrease the work rate [8]. Therefore, it is crucial for every employer to provide training and the
comprehensive safety programs [7] which can improve safety performance continuously to reduce potential hazard in construction project.

Some researchers suggest that measuring contractors’ own safety performance is important to ensure their organizations are aware of their safety well-being. A study by Hinze and Gambatese [9] concluded that contractor’s safety performance was consistently influenced in part by a number of factors. In addition, the quality of project contractors is even more important because it has a direct bearing on the performance of the prime contractors on key elements of the work [10]. Improving OHS performance in the construction industry is crucial because it represents the excellence of the executed projects, and more importantly the protection of life for people who work in the field [11-14]. Traditionally, safety performance was measured by the goal-setting and feedback method (known as lagging indicators) such as Incident Rate (IR), Accident Rate (AR) and Experience Modification Rate (EMR). In recent years, leading indicators have been highlighted as the method to evaluate safety performance of the construction project [15]. Safety performance measurement tool has been developed in other countries, for example ‘Safety Meter’ in Australia. The tool is based on leading indicators that aim to involve the workforce in the method of measurement and raise site safety awareness [16].

In Malaysia, it is believed that the study on safety performance measurement is still lacking. Even though there exist a tool named SHASSIC developed by Construction Industry Development Board (CIDB) to measure the performance of safety and health of construction industry, the indicators or factors underpinning the tool are not comprehensive [4]. The indicators or factors in SHASSIC are more organisation-wise, such as OSH policy and OSH organisation, with the lacking in project-wise indicators, such as the implementation of audit and safety personnel. Therefore, there is a gap in existing study need to be addressed towards a more comprehensive safety performance measurement framework which takes into account factors pertinent to an organisation and its projects. As a stepping stone for the framework development process, this study seeks to identify the factors affecting safety performance in construction project, pertinent to project levels.

2. Literature Review

2.1. Construction safety management

Construction safety management is a method of controlling safety policies, procedures and practices on construction site [17]. According to Cheng et al. [18], the process involve from dynamic by small or large adjustment made to site environment to normal business. Moreover, every level of company or part of a cross-organization project should apply safety as management concept. The construction management should consider a safety culture and safety climate is important aspect should be concerned [19].

Occupational safety and health management on construction site has unique of challenges. Despite to the challenges, the incidents can be reduce through well-structured and well-funded by safety programmes and techniques applied from firms [26]. In addition, safety management should be often adjusted due to industrial needs. Hallowell and Gambatese [26] stated that most of company allocates limited resources for safety management and contractors are forced to carefully select from the available elements. Therefore, good safety procedures reflect in maximizing the safety performance of construction safety in site. According to Jaselskis et al. [27], construction safety management techniques significantly improve by following the safety related act which highlights the responsibility for construction safety on employers and increase in safety planning also in management efforts on construction industry. Improving safety performance in the construction industry is crucial because it represents not just the excellence of the executed projects, but more importantly the protection of life for people who work in the field [4].

2.2. Safety performance of construction industry

Generally, safety performance is often evaluated based on negative indicators such as accident number, days lost, injury rates and accident cost. The importance of evaluating safety performance is to gauge the effectiveness of construction firms’ management in accident prevention by setting out safety objectives and targets [28]. When a project experiences high accident rates, the contractor involved can
develop a poor reputation, though the size of the company does contributes to the safety performance of construction contractors [17, 23]. Therefore, both large and small contractors have an obligation to maintain their reputation in health and safety by maintaining their safety performance.

Abas [4] quoted:

“Jaselskis et al. [21] provided strategies for achieving better construction safety performance and project level, and emphasized that safety performance measurement is most effective when using both ‘quantitative and qualitative’ safety measurements. Whilst quantitative measures include lost time, severity rates, and Experience Modification Rating (EMR) – a method used to calculate insurance premiums for workers due to accidents; qualitative measures consist of outstanding, average and below-average performances, as determined by OHS assessors. In their study, Jaselskis et al., [21] presented numerical profiles of companies and projects with verifying levels of safety performance at the company and project level, and recommended through their findings, that there are several factors that were significant to achieve better safety performance at both levels. For company level, such factors include upper management support, time devoted to safety issues for the company safety coordinator, number of safety inspections, meeting with the fields safety representatives and craft workers etc; whereas for project level, some important factors include increased project manager experience level, more supportive upper management attitude towards safety, reduced project team turnover, increase time devoted to safety for the project safety representative etc. [21]. This is supported by Jafri et al [24] who proposed the evaluation of safety performance to be evaluated based on the leading indicators and outcome (lagging) indicators.”

Table 1 represents the several authors’ perspectives on safety indicators while measuring the safety performance. Safety performance is deemed as the effectiveness of leading indicators, and the impact of those indicators to safety performance will determine the outcome [24]. By evaluating safety performance using leading indicators and observing the outcome using lagging indicators, the potential hazards can be identified at an early stage and therefore unnecessary losses in life and cost can be avoided [25]. Furthermore, current strength and weakness can be identified by continuously auditing and reviewing the management systems and operational practices in order to achieve high safety performance [25]. For instance, in Australia implementation of performance measurement by using safety meter was developed. This tool is based on leading indicators that aim to involve the workforce in the method of measurement and raise site safety awareness [16]. Thus, measuring leading indicators and get the result can help to improve safety.

Table 1 shows some of the perceived safety indicators while measuring safety performance. It is to be highlight of that the Construction Industry Development Board (CIDB)’s indicators are extracted based on government documents, not from sources of research.

| Authors | Leading indicator | Lagging indicator |
|---------|-------------------|------------------|
| Dyck D, Roithmayr T [15] | Regular safety audit conducted, good injury record keeping. | Number of accidents at work or accidents frequency rates, workers’ cost compensations, number of days of absence due to accidents at work, number of occupational diseases etc. |
| Salminen et al, [26] | Safety audits, toolbox meeting, owner promotion, pre-task planning, drug test, number of close calls, worker observation records. | Accident cost analysis, injury/incident rates. |
| Jafri et al. [24] | Safety culture, behavior-based indicator, management involvement, employee empowerment, employee perception survey, safety audits, root cause analysis. | Accidents number, injury rates, days lost, accidents costs. |
| Lin & Mills [23] | Health and safety systems, managements responsibility, contract review, design control, work method control, purchasing, inspection and testing, corrective and prevention action, | Severity rates, lost time injury |
control on non-conformance, health and safety records, health and safety auditing, statistical techniques, training

| CIDB [27] | OSH organization, OSH policy, Risk Assessment and Risk Control (HIRARC), Hazard Identification, machinery management, training and promotion, material management, accident investigation and reporting, Emergency Response Plan (ERP), record management and performance monitoring | N/A |

2.3. Factors affecting safety performance of construction project

According to Thomas et al. [22], there are two levels which affecting safety performance in construction industry which are ‘project level’ and ‘organizational level’. The factors that affect safety performance of construction project are discussed in the next section, pertinent to these two categories.

2.3.1. Project level. The project level is known as the owner’s decision to divide the work program with several inter-firm organizations [22]. Safety on construction project is related with historical factors which include economy, psychology, technical, procedure, organization and environmental work issues [14]. Ng et al. [22], in an attempt to develop the framework for safety performance evaluation, has summarized the factors that affect construction project safety performance on project level, as below (Note that the summary of factors are supported by relevant literatures):

i) **Implementation of safety inspection** - Safety inspection is the main tool to maintain safe condition on site and monitor the unsafe practices at workplace. Permana [28] affirmed that safety inspection is very essential to safety practices based on the study he did in Batam, Indonesia, which is also supported by Kai et al [29] and Tan and Razak [30].

ii) **Implementation of safe system of work** – According to Ismail [31], any safety program should be based on a policy insisting on the safety protection and safe system of work to the employees. Apart from that, serious enforcement of the written policy has to be made especially for high rise building project Khairolden et al. [32]. It is because all the contractors and workers can aware to the equipment and structures at workplace that hazardous to themselves or even public.

iii) **Implementation of safe plant & equipment** - PPE is worn by a person at work to protect him against risk to safety and health and any additional accessory designed to protect him while performing task. It is important to provide PPE to workers at construction sites in order ensure a safe and healthy condition at the workplace [33-34].

iv) **Implementation of safe working environment** - Bakri et al. [36] highlighted that providing a safe and healthy workplace as the most effective strategies to maintain the cost of construction project. Failure to adhere to safe working environment implementation could result in accident that may increase the project cost.

v) **Implementation of safety officer & supervisor** – In order to ensure better construction safety, an employer should appoint full-time safety and health officers (SHO) and site safety supervisors (SSS) with specific jobs such as conducting site safety tours and inspections [37, 38]. The appointment of both SHO and SSS is depend on the project scope that includes project value, in accordance with the legislations. This is supported by Jannadi [39] and Lee and Halpin [40] that site safety supervision and the provision of a safe environment are the factors related to the implementation of safety systems at construction site.

vi) **Safety review for safety audit** - A safety audit includes safety inspections, inspection of documents and interviews [41]. Safety audit is important to check the organization’s level of compliance with OSH legislations, thus provide a safe workplace.

vii) **Safety review for site safety policy review** - Griffith and Howarth [42], defined the safety policy as a published statement reflecting the organization’s vision and mission in relation to the management of health and safety matters.
viii) **Emergency plan and procedures** - emergency drill should be conducted once in every three months which all the workers will be given a briefing on emergency procedures [42]. Attendance of the workers at the designated assembly area should be also recorded.

ix) **Safety training** - According Paringga [35], education and training designed to prevent human error that may cause the accidents and to enable workers to perform a repetitive task with skill. In addition, Lai et al., [43] also stated that safety training is the most effective tool to mitigate hazards since training helps to improve worker’s skills and abilities to identify hazards. Tsui and Gomez-Mejia [44] also stated that one way to encourage employee safety is to involve all employees at various times in safety training through regular sessions with supervisors, managers, and employees which should often coordinated by HR staff members. The statement also supported by other scholars such as Permana [28], Kai et al [29] and Tan and Razak [30].

Table 2 depicts the summary of the factors affecting safety performance in construction project pertinent to project level. It could be seen that safety training is the most cited factor in project level that affects safety performance of construction project. By conducting regular training on the workers for the particular project, safety performance can be improved and further, reduce the number of accident. In order to ensure the successfulness of the training program to improve safety performance, safety training must be conducted to all construction and building site workers in a project, as such to enhance awareness about safety in workplace.

Other most frequently cited factors are implementation of safe working environment, implementation of safe working plant and equipment and safety review for site safety policy. This could be done by providing means to ensure safe working environment, plant and equipment, such as through specific program that can encourage safety culture, periodical inspection of the workplace and establishing safer work practices. Both employer and employee at the workplace must comply with any legislative requirements related to safety and health.

3. **Conclusions**

In conclusion, through literature review, there are several identified factors that can affect the safety performance of construction project in project level. There are many advantages by implementing these safety factors, such as reduce the number of accident on the construction project, increase productivity, project complete on time, and decrease compensation cost and increase morals among employees. The good safety performance in project level can lead to better improvement of safety performance in construction industry. Future research is needed to explore the factors affecting safety performance in organization level.
Table 2. Summary of the factors affecting safety performance in construction project pertinent to organisation level.

| Factors affecting safety performance in project level | Implementation of safety inspection | Implementation of safe system of work | Implementation of safe plant & equipment | Implementation of safe working environment | Implementation of safety officer & supervisor | Safety review for safety audit | Safety review for site safety policy | Emergency plan & procedures | Safety training | Accident investigation | Site safety meeting |
|------------------------------------------------------|-------------------------------------|--------------------------------------|-----------------------------------------|-------------------------------------------|---------------------------------------------|--------------------------------------|-----------------------------------|-------------------------------|----------------|----------------------|------------------------|
| Tsui and Gomez-Mejia [44]                            | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Mattila et al [45]                                   | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Jannadi et al [39]                                   | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Tam and Fung [46]                                    | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Sawacha et al [47]                                   | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Abudayeh et al [48]                                  | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Hislop [49]                                          | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Kartam et al [50]                                    | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Griffith and Howarth [42]                            | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Jannadi and Bu-Khamsin [51]                          | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Al-Kaabi and Hadipriono [52]                         | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Reese [53]                                           | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Lee and Halpin [54]                                  | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Hinze and Gambatese [9]                              | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Tam et al. [55]                                      | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Fang et al [56]                                      | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Teo et al [58]                                       | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Cheng et al [18]                                     | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| DOSH [33]                                            | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Ismail [31]                                          | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Bakri et al [36]                                     | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Permana [28]                                         | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Ghani et al [32]                                     | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Ahmad [34]                                           | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Yung [38]                                            | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Paringgga [35]                                       | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Nikolaos [41]                                        | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Lai et al [43]                                       | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Kenrick [59]                                         | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Tan and Razak [30]                                   | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Kai et al [29]                                       | /                                   | /                                    | /                                       | /                                         | /                                           | /                                    | /                                 | /                             | /               | /                    | /                      |
| Frequency                                            | 5                                   | 4                                    | 5                                       | 6                                         | 4                                           | 1                                    | 4                                 | 3                              | 12              | 1                    | 2                      |


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