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Construction Safety Assessment Framework for Developing Countries: A Case Study of Sri Lanka

Kanchana Priyadarshani, *Gayani Karunasena and Sajani Jayasuriya

Abstract: Construction safety on project sites is of utmost importance due to the nature of the construction industry. However, it is usually a secondary concern in a market-driven society where the main concern is completing projects at the required quality with minimum time and cost. Thus, safety issues are considered only after an accident occurs at a construction site with follow up measures to improve working conditions, especially in developing countries. In Sri Lanka, according to the International Labour Organisation, one out of six accidents and 25 out of 40 deaths occur at construction sites due to negligence or carelessness. These statistics show that safety is not adequately considered in the Sri Lankan construction industry. Therefore, proper safety management in construction is of utmost importance; hence, this study aims to introduce a benchmark to measure construction safety through a proposed safety management assessment framework. Factors affecting construction safety performance were explored through a questionnaire survey conducted in Sri Lanka. The results suggest that a benchmark of construction safety should be considered across six dominant groups of factors: management commitment, management measures, implementation, project nature, individual involvement and economic investment. Management commitment is the most dominant factor that affects construction safety and consists of implementing organisational safety policies, assigning safety responsibilities at all levels, etc. The proposed management framework will facilitate a benchmarking process and initiatives for improving construction safety performance in developing countries.

Keywords: Construction safety, Developing countries, Safety management, Safety factors, Sri Lanka

INTRODUCTION

Workplace safety is a core consideration for all types of organisations that are accountable for protecting and optimising the functionality of human resources. In regard to construction, ensuring workplace safety is not an easy task. Occupational accidents in the construction industry cause economic and social problems in organisations, as well as countries (Rubio et al., 2005). Among all industries, construction has the highest rate of accidents, including deaths and disabling injuries, worldwide (Koehn, Kothari and Pan, 1995; Fang, Song and Huang, 1999; Ahmed et al., 2000).

Although it is difficult to quantify labour accidents on a global scale, a study by López-Valcárcel estimated that approximately 350,000 workers die every year due to labour accidents. Of these accidents, 60,000 occur in the construction industry worldwide (López-Valcárcel, 1996). Farooqui, Arif and Rafeeqi (2008) compared fatality rates (deaths per 100,000 employees) in global scenarios of all industries to that of construction industry in 2002 and discovered that the fatality rate in the construction industry is relatively high compared to other industries. In Hong Kong, the fatality rate in the construction industry is 64.2, while it is 8.6 across

Department of Building Economics, University of Moratuwa, Moratuwa, SRI LANKA
*Corresponding author: gayani@becon.mrt.ac.lk

all other industries. In Canada, it is 6.1 in all industries but 20.9 in the construction industry. The fatality rates are higher in the construction industry than in all other industries in Australia, Sweden and United Kingdom. These statistics clearly indicate the unsafe nature of the construction industry (Farooqui, Arif and Rafeeqi, 2008). In Sri Lanka, as in other countries, the extent of construction accidents is more severe when compared to other industries (Rameezdeen, Pathirage and Weerasooriya, 2003).

Efforts have been made to address this problem, but the results are far from satisfactory as construction accidents continue to dominate. Despite programmes implemented by government authorities at a national level and the initiatives of private companies, the number of construction accidents remains alarmingly high (Teo, Ling and Chong, 2005). It is evident that these efforts are not sufficient to control the occurrence of unsafe acts at construction sites.

According to Sawacha, Naoum and Fong (1999), accidents at work occur either due to lack of knowledge, training or supervision, lack of means to carry out a task safely, errors in judgment, carelessness, laziness or total irresponsibility. In addition, the lack of a controlled working environment and the complexity and diversity of the sizes of organisations have an effect on safety performance in the industry (Sawacha, Naoum and Fong, 1999). De Silva, Rajakaruna and Bandara (2008) found that inadequate safety precautions, non-implementation of rules, limited funds, deficient knowledge and unqualified officers cause unexpected accidents in the construction industry in Sri Lanka. Furthermore, according to an annual report published in 2002 by Institute of Construction Training and Development (ICTAD), the safety practices adopted at construction sites are far below acceptable standards (ICTAD, 2002). Additionally, the low educational level of many construction workers is a barrier to improving safety at construction sites in Sri Lanka.

The challenge is to determine the predominant factors and develop a benchmark for measuring safety management in the construction industry to foster safe working environments at construction sites. The key factors influencing safety management have not previously been the focus of research, and to date, no safety management framework has been formulated as a benchmark for construction safety management in developing countries. Thus, the aim of this study is to develop a method for measuring safety management on construction sites by identifying factors that affect construction safety performance. The final objective is to provide a framework for safety management that can be used as an effective tool for improving safety management at construction sites.

The next section will present a comprehensive literature review of the relevant theories associated with construction safety management in general. Subsequently, the design of a framework to foster safe work environments in the construction industry is discussed. The research methodology is then presented, followed by the results. The safety management framework was developed to establish a benchmark that can be applied within construction sites to ensure proper management of construction safety.

CONSTRUCTION SAFETY MANAGEMENT

Construction site safety is no longer a term merely associated with technical issues. Emphasis is placed on how project management can help improve site safety (Suraji, Duff and Peckitt, 2001). Safety management is now integrated into project management.

Construction Safety Management is a method of controlling safety policies, procedures and practices on construction sites (Wilson and Koehn, 2000). It is a dynamic process involving small or large adjustments made to site operations to achieve the desired goals without encountering unexpected "shocks" to normal business (Cheng et al., 2004). Furthermore, safety should be embedded as a management concept into every level of a company and every part of a cross-organisational project. When considering construction safety management, "safety culture" and "safety climate" are two important aspects (Flin et al., 2000). Safety culture is preceded by an extensive body of research into organisational culture and climate; culture embodies values, beliefs and underlying assumptions, and climate is a descriptive measure that captures the workforce's opinion of the organisational environment (Gonzalez-Roma et al., 1999).

Safety can also be viewed as a broad quality measure (Walker et al., 2001). Pheng and Shiua (2000) stated that the industry not only aims for good quality buildings but is also keen to promote safe working environments at construction sites because quality and safety are two important aspects of a construction project. Unfortunately, both are frequently considered separately. Instead of operating two separate management systems, synergy can be achieved by integrating quality and safety into a common platform.

Management of occupational safety and health in construction has unique challenges. Despite such challenges, firms that demonstrate commitment to well-structured and well-funded safety programmes and techniques can effectively reduce incidents (Hallowell and Gambatese, 2009).

Safety management techniques must often be adjusted to meet the unique needs of the industry. Because most firms allocate limited resources for safety management, contractors are forced to carefully select from the available elements (Hallowell and Gambatese, 2009). To effectively manage construction safety, adherence to safety procedures is important when maximising safety performance. According to Jaselskis, Anderson and Russell (1996), construction safety management techniques improved significantly following the Occupational Safety and Health Act of 1970. This act placed the responsibility for construction safety on employers and resulted in a dramatic increase in safety planning and management efforts in the construction industry.

MEASURING CONSTRUCTION SAFETY PERFORMANCE

To overcome the limitations associated with existing methods, other measures of safety performance can be implemented (El-Mashaleh, Rababeh and Hyari, 2009). There are several methods for measuring safety performance at construction sites:

1. Apply the concept of profiling, which consists of developing a corporate safety performance standard in a number of categories that are considered important by the clients' project managers. Companies are then compared according to these categories, and a profile is developed (Fletcher, 1972).
2. Conduct a safety audit as a comprehensive review of the company's safety programme. A properly conducted safety audit will determine the strengths and weaknesses of a current safety programme (Kavianian and Wentz, 1990).
3. Injury frequency, which is the number of lost-time injuries per million hours of exposure, is also a method of measuring safety performance (Jannadi and Al-Sudairi, 1995).

Additional models for measuring the effectiveness of safety management systems at construction sites have been developed in countries such as Singapore, Hong Kong and China (El-Mashaleh, Rababeh and Hyari, 2009; Chan, Chan and Choi, 2010). A decision support tool called *ToolSHeDe* was developed for the Australian construction industry to help designers integrate management of OHS risks into the design process (Cooke et al., 2008). Accident Rate (AR), Incident Rate (IR), Experience Modification Rate (EMR) and Score Card (SC) systems are some safety evaluation methods that have been introduced for better safety management. As Tam and Fung (1998) mentioned, the use of AR is inferior to the use of other indices because it measures performance simply by the number of accidents; it has been regarded as an unsound basis for comparison. The accuracy of IR depends on how honest a contractor is in revealing accidents, illnesses, fatalities and injuries. EMR is the ratio between actual claims filed and expected claims for a particular type of construction (Ng, Cheng and Skitmore, 2005). EMR formulae are relatively complex, and different versions of the calculations exist in practice, making EMR an inappropriate measure of safety performance for all types of companies (Hinze, Bren and Piepho, 1995).

Although there are established, standardised checklists to assess both physical and technical safety aspects at construction sites, these checklists do not assess management aspects. The conventional benchmarking approach in construction safety involves assessing safety performance by evaluating the physical safety conditions at a site, as well as accident records, but pays no attention to the management factors that influence site safety (Fang, Huang and Hinze, 2004). Thus, an effective measure or benchmark of safety management is an important element in improving safety management. It should facilitate assessing site safety and provide guidance with regard to prioritising safe management measures on construction sites.

FACTORS AFFECTING CONSTRUCTION SAFETY PERFORMANCE

Many research efforts on construction safety have focused on the factors that affect construction safety. These efforts identified a variety of ways that supervisors and managers of construction companies can impact the safety performance of a construction project. Most companies follow established safety guidelines and policies that meet Occupational Health and Safety guidelines. However, most incidents and injuries at construction sites are a direct result of not adhering to the established safety procedures; hence, construction safety performance can be affected by several factors.

Table 1 presents the factors that affect construction safety performance. Insufficient or lack of safety training is a managerial issue that can negatively affect construction safety performance, while conducting safety meetings, monitoring safety performance and inserting safety issues in regular meetings are other factors identified by Jannadi (1996) and Jaselskis, Anderson and Russell (1996). Post-accident investigations, safety campaigns and incentive schemes are management measures that can be implemented to improve construction safety performance (Tam and Fung, 1998 as cited in Yung, 2009).

It is vital to foster the commitment of managerial level employees to construction safety performance. Strong top management support and good labour relations affect construction safety performance (Jannadi, 1996; Fang, Huang and Hinze, 2004; Hinze and Rabound, 1988 as cited in Yung, 2009). Organisations can assign safety responsibilities to all employees to ensure construction safety (Jannadi, 1996). Company safety policies and safety management systems in accordance with relevant legislation can positively affect construction safety performance (Ng, Cheng and Skitmore, 2005; Teo, Ling and Chong, 2005 as cited in Yung, 2009).

Full-time safety officers and project safety officers can be appointed, and specific job site safety tours and inspections can be conducted to ensure better construction safety (Hinze and Rebound, 1988 as cited in Yung, 2009). According to studies by Jannadi (1996) and Lee and Halpin (2003) (as cited in Yung, 2009), site safety supervision and the provision of a safe environment are factors related to the implementation of safety systems at construction sites. The involvement of each and every individual at a construction site is a major factor in construction safety performance (Hinze and Gambatese, 2003 as cited in Yung, 2009; Fang, Huang and Hinze, 2004). An effective safety management framework was developed based on the above studies, and the factors affecting construction safety management are illustrated in Figure 1.

Table 1. Factors Affecting Construction Safety Performance

Year	Author	Factors affecting construction safety
1988	Hinze and Rabound	Employment of full-time safety officers
		Stronger upper-management support for safety
		Conducting safety meetings for supervisors
		Monitoring safety performance of supervisors
		Employment of project safety officers
		Conducting specific job site safety tours
		Inclusion of safety issues in regular meetings
		Employment of sophisticated scheduling methods
		Presence of owner in coordination meetings
		Lack of budgetary constraints

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Table 1. (*continued*)

Year	Author	Factors affecting construction safety
1996	Jannadi	Maintaining safe work conditions Establishing safety training Educating workers and supervisors in developing good safety habits Effective control of the numerous subcontractors by the main contractor Maintaining close supervision of workers Assignment of responsibility to all levels of management and workers
	Jaselskis, Anderson and Russell	Upper management support Time devoted to safety issues by the company safety coordinator Number of informal safety inspections made by the company safety coordinator Meetings with field safety representatives and craft workers Safety training for new foremen and safety coordinators Specialty contractor safety management Company safety expenditures Increased project manager experience level Supportive upper management attitudes on safety More formal meetings with supervisors and specialty contractors Number of informal site safety inspections Reduced craft worker penalties Increased budget allocation to safety awards
1998	Tam and Fung	Provision of safety training The use of directly employed labour The use of post-accident investigation as feedback Promoting safe practices by safety award campaigns and incentive schemes
1999	Mohamed	There was no strong positive correlation between commitment to safety management and any of the safety performance and pro-activeness variables
	Sawacha, Naoum and Fong	Management talks on safety Provision of safety booklets Provision of safety equipment Providing a safe environment Appointing a trained safety representative at site

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Table 1. (*continued*)

Year	Author	Factors affecting construction safety
2003	Hinze and Gambatese	Growth in company size
		Safety intensive programmes were not necessarily associated with better safety performance
	Lee and Halpin	Preplanning
		Supervision
		Training
2004	Cheng et al.	Lack of attention to safety protection by workers
		Lack of attention to safety management by main contractors/project managers
		Insufficient safety training
		Inadequate safety level
		Tiredness of workers
		Poor quality of construction materials and equipment
	Fang, Huang and Hinze	Organisational structure
		Economic investment
		Labour-management relations
	Tam, Zeng and Deng	Poor safety awareness of firm's top leader
		Lack of training
		Poor safety awareness of project managers
		Reluctance to allocate resources toward safety
		Reckless operation

Source: Yung (2009)

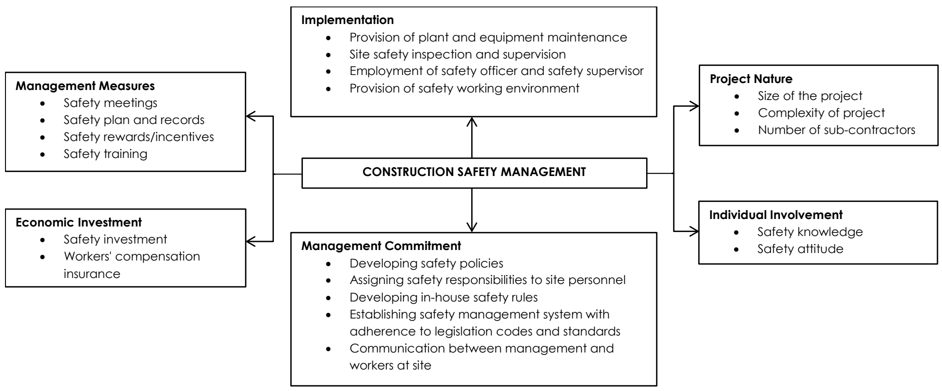

Figure 1. Construction Safety Management Framework

CONSTRUCTION SAFETY MANAGEMENT SYSTEMS IN DEVELOPING COUNTRIES

Protecting labour from occupational diseases and accidents in construction industry is defined by law in developing countries. At construction sites employing 50 or more workers, the main contractor must nominate a full-time safety inspector: for sites with an area exceeding 10,000 m^2, there must be two to three safety inspectors; for sites with an area exceeding 50,000 m^2, the main contractor must establish a safety management team (Tam, Zeng and Deng, 2004). In Botswana, clients' attitudes and actions reveal that they consider Health and Safety as insignificant factors in considering construction projects (Musonda and Smallwood, 2008). Farooqui, Arif and Rafeeqi (2008) used the Safety Performance Index to benchmark industry performance; they found that even the basic practices required for safety are not present at most construction sites in Pakistan.

According to Jain (2007), construction safety management is a challenging task due to the dynamic nature of construction activities coupled with the involvement of an unskilled, illiterate and mobile work force in India. Jain (2007) stated that, in India, surrounding populations who are generally from an agricultural background and only speak and understand local languages become involved in construction activities. Hence, these factors also create additional challenges due to limited communication. Furthermore, construction is rated to be eight times more risky the manufacturing sector in India (Jain, 2007). Permana (2007) stated that workers have not been protected because safety regulations have not been thoroughly established, particularly in construction industries in Indonesia. Furthermore, he mentioned that construction accidents are continuously increasing in Indonesia.

Despite all of these factors, some researchers have developed Safety Management Systems to improve the safety performance at construction sites in developing countries. The Safety Culture Improvement Matrix is to be used as a self-assessment tool (Wright et al., 1999). The Balanced Scorecard tool assesses and benchmarks organisational safety culture as some of its outcomes (Mohamed, 2003). It has been argued that a performance measurement tool, which has a number of different but complementary perspectives, would enable organisations to pursue incremental safety performance improvements (Chinda and Mohamed, 2008). In Hong Kong, the Pay for Safety Scheme (PFSS) is an effective safety measures programme. Under PFSS, the "Site Safety" section of the bill of quantities covers all of the payable safety items (Choi, Chan and Chan, 2011). Approximately 2% of a contract sum is set aside for contractors to implement safety-related items. However, the fixed sum may be adjusted depending on the size of project. By encouraging the contractor to perform these necessary safety measures and items from the tender stage through project completion, PFSS is eventually expected to improve the overall safety performance of projects (Chan, Chan and Choi, 2010). The Score Card system introduced by Martinsons, Davison and Tse (1999) is not based on a solid research foundation, but it calculates weightings for each factor addressed in the study.

These developed frameworks provide guidelines for developing countries to assess safety management at construction sites. However, there is a need to assess factors affecting construction safety management from a managerial perspective, where the above-developed framework (Figure 1) can be used by key decision makers in construction projects.

RESEARCH METHODOLOGY

Data Collection

To devise a rational framework for safety management necessities, the establishment of the importance of safety factors is essential. A questionnaire survey with a 5-point Likert scale was chosen over other methods, such as Analytic Hierarchy Process (AHP) or Delphi, because of the views of various project participants.

When developing the questionnaire, safety factors identified through previous studies were considered (see section 4). The questionnaire consists of two sections: one (section A) concerns the importance of the main categories (see Figure 1), and the other (section B) addresses the evaluation of each main category with sub factors. A Likert bipolar scale of 1–5, where 1 is very low, 2 is low, 3 is medium, 4 is high and 5 is very high, was provided to gather and analyse the level of importance of each factor. Naoum (1998) stated that a data set is said to be ordinal when the values assigned need to be ranked and the intervals between values may not necessarily be equal or represent actual quantities. Bendixen and Sandler (1995) asserted that an ordinal scale can be considered as an interval scale provided that the distance (interval) between adjacent points is equal when a scale has at least five or seven categories (Garson, 2007). However, a 1–5 point Likert scale is preferred for this study because it creates a level of importance for each factor, while the 1–7 scale creates end values, such as not applicable. Because this study seeks to evaluate each factor of the construction safety framework in terms of its level of importance, a 1–5 Likert scale was applied rather a 1–7 scale. Furthermore, there is no rule regarding the use of four-point, five-point, seven-point or ten-point scales because the aim is targeted at the sensitivity of responses (Tan, 2002; Sarantacos, 1998; Spector, 1992).

Because the results of a study depend exclusively on the responses of the sample, the selection of experts was deemed to be of utmost importance (Shapira and Simcha, 2009). Thus, experts were expected to have extensive working experience in the construction industry, be currently or recently directly involved in construction safety management and have a detailed knowledge of overall safety aspects. The target population from which the sample was selected was composed of prominent professionals who had been engaged in construction safety management within Sri Lanka for at least 10 years. Professional project managers, civil engineers, quantity surveyors, architects and safety supervisors were selected from both consultancy and contracting firms, as indicated in Table 2.

A random sample of 40 prominent professionals was selected from the construction industry based on their working experience; from this sample, 36 responses were received, which corresponds to a response rate of more than 90%. According to Chan et al. (2001), the sample or group size could be from 10 to 50 participants.

The next section explains the analytical tools used to identify the importance and relative significance of the safety factors that were ultimately utilised to develop the proposed safety framework.

Table 2. Questionnaire Response Rates

Organisation Type	No. of Issued Questionnaires	No. of Received Questionnaires	Response Rate
Consultancy Org.	20	17	85%
Architects	5	4	
Civil Engineers	5	4	
Quantity Surveyors	5	5	
Project Managers	5	4	
Contracting Org.	20	19	95%
Civil Engineers	5	5	
Quantity Surveyors	5	5	
Project Managers	5	5	
Site Supervisors	5	4	

Data Analysis

Importance of main factors

The data collected from the questionnaire survey were analysed according to the Mean Score (MS), as performed by Ng et al. (2005):

$$MS = \frac{\sum f \times s}{N} (1 \le MS \le 5) \qquad \text{Eq. 1}$$

where
f = frequency of responses rating each main factor,
s = score given to each main factor by the respondents and
N = total number of responses concerning that factor.

The MS was then used to determine the Relative Importance (RI) of each main factor by

$$RI(M)_j = \frac{MS_j}{\sum_{j=1}^{N} MS_j} \qquad \text{Eq. 2}$$

where
$RI(M)_j$ = relative importance of the j^{th} main factor and
MS_j = mean score of the j main factor.

The results reveal that all six main factors are important for construction safety management because the MS of the results are greater than the median value "3". "Management commitment" is the most important main factor, while "economic investment" is the least important one (see Figure 2). The results of MS and the RI for the main factors are illustrated in Table 3. Next, the results for the sub factors are revealed.

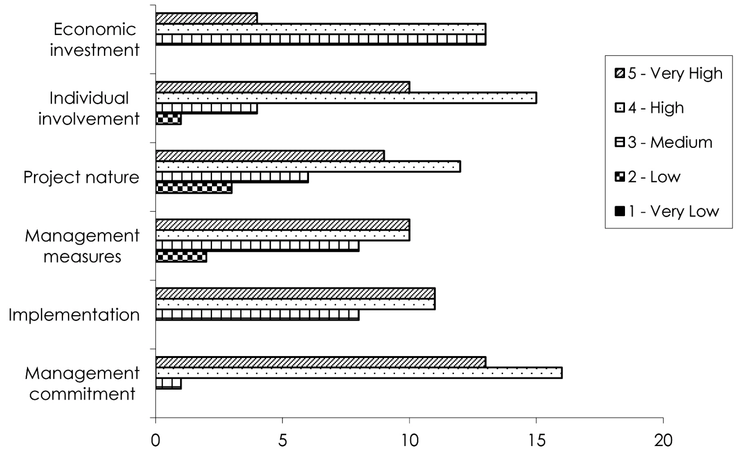

Figure 2. Degree of Importance

Table 3. Summary of the Mean Scores of Main Factors

Factors	**MS**	**Relative Ranking**	**RI**
Management commitment	4.40	1	0.182
Implementation	4.10	3	0.170
Management measures	3.93	4	0.163
Project nature	3.90	5	0.161
Individual involvement	4.13	2	0.171
Economic investment	3.70	6	0.153

Importance of sub factors

To establish the importance of each sub factor, MS was computed using the same formula used above, where f = frequency of responses rating each sub factor, s = score given to each sub factor by the respondents and N = total number of responses concerning that factor. Then, the RI of each sub factor was calculated as follows:

$$RI(S)_{ij} = \frac{MS_{ij}}{\sum_{i=j}^{N} MS_{ij}} \quad \text{Eq. 3}$$

where
$RI(S)_{ij}$ = relative importance of the i^{th} sub factor under the j^{th} main factor and
MS_{ij}= mean score of the i^{th} sub factor under the j^{th} main factor.

Table 4 summarises the mean scores and rankings of each sub factor. Among sub factors, "complexity of project" under the main factor "project nature" is the most important, while "safety rewards/incentives" under "management measures" is of the least importance. Sub factors such as "workers' compensation insurance", "safety training", and "conduction of site safety inspection and supervision" can also be mentioned as crucial factors in managing construction safety.

Accordingly, the questionnaire survey results revealed that all sub factors and main factors are important for safety management because the values of MS are greater than the median. These results prove the theoretical outcomes identified in the literature review.

SAFETY MANAGEMENT ASSESSMENT FRAMEWORK

In developing the Safety Management Assessment Framework, a Performance Index (PI) for each sub factor is calculated, as in Ng, Cheng and Skitmore (2005). The RI of each sub factor and its corresponding main factor are combined with the weight score to generate a Performance Index. The PI represents the score that could be assigned to each factor according to the actual safety performance:

$$\mathrm{PI}_{ij} = \frac{PW \times \mathrm{RI}(S)_{ij} \times \mathrm{RI}(M)_j}{4} \times 100 \qquad \text{Eq. 4}$$

where
PI_{ij} = performance index of the i^{th} sub factor under the j^{th} main factor and PW = weighted score of different safety performance levels with 1 = Poor, 2 = Satisfactory, 3 = Good, 4 = Very good.

After calculating all of the potential index values for each sub factor under each performance scenario, the Safety Management Assessment Framework was developed according to the RI calculated above (Table 5). As an example, the index value for very good performance in "developing safety policies" can be calculated as follows:

$$\mathrm{PI}_{\textit{Developing safety policies}} = \frac{4 \times 0.197 \times 0.182}{4} \times 100 = 3.60 \qquad \text{Eq. 5}$$

Based on the above Total Performance Score, benchmarks are established as follows:

1. if the total score (or average score) is < 100, the performance is poor;
2. if the total score (or average score) is between 100 and 225, the performance is satisfactory; and
3. if the total score (or average score) is > 225, the performance is good.

Furthermore, if the total score (or average score) is equal to 400, the performance is very good.

These findings may help the various stakeholders of a construction project to more effectively manage construction safety because those factors may facilitate making key decisions in a project. When safety aspects are well managed, the frequency of accident occurrences can be reduced. Additionally, this research provides effective and efficient guidelines on construction safety for construction organisations, and the framework has also been tested by collecting feedback from industry experts. The experts' opinions of the proposed safety assessment framework and its implications for industrial and academic development are included in the concluding remarks.

Table 4. Summary of Mean Scores of Sub Factors

Factors	**MS**	**Relative Ranking**	**RI**
Management Commitment			
Developing safety policies	4.17	10	0.197
Assigning safety responsibilities to site personnel	4.27	7	0.202
Developing in-house safety rules	4.27	7	0.202
Establishing safety management system with adherence to legislation codes and standards	4.30	5	0.204
Communication between management and workers at the site	4.10	11	0.194
Implementation			
Provision of plant and equipment maintenance	3.90	14	0.235
Conduction of site safety inspections and supervision	4.37	2	0.263
Employment of safety officer and safety supervisor	4.10	11	0.247
Provision of safe working environment	4.23	9	0.255
Management Measures			
Safety meetings	3.83	16	0.246
Safety plans and records	3.87	15	0.248
Safety rewards/incentives	3.50	20	0.225
Safety training	4.37	2	0.281
Project Nature			
Size of project	3.57	18	0.303
Complexity of project	4.47	1	0.380
Number of subcontractors	3.73	17	0.317

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Table 4. (*continued*)

Factors	MS	Relative Ranking	RI
Individual Involvement			
Safety knowledge	3.97	13	0.480
Safety attitude	4.30	5	0.520
Economic Investment			
Safety investment	3.57	18	0.450
Workers' compensation insurance	4.37	2	0.550

Table 5. Safety Management Assessment Framework

Factors Affecting Construction Safety Management	Poor x 1	Satisfactory x 2	Good x 3	Very Good x 4	Score	Total
Management Commitment						
Developing safety policies	0.90	1.80	2.70	3.60		
Assigning safety responsibilities to site personnel	0.92	1.84	2.76	3.68		
Developing in-house safety rules	0.92	1.84	2.76	3.68		
Establishing a safety management system in adherence to legislation codes and standards	0.93	1.86	2.78	3.71		
Communication between management and workers at site	0.88	1.77	2.65	3.54		Subtotal 1
Implementation						
Provision of plant and equipment maintenance	1.00	1.99	2.99	3.99		
Site safety inspections and supervision	1.12	2.23	3.35	4.46		
Employment of safety officer and safety supervisor	1.05	2.10	3.14	4.19		
Provision of safety working environment	1.08	2.16	3.24	4.33		Subtotal 2

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Table 5. (*continued*)

Factors Affecting Construction Safety Management	**Poor x 1**	**Satisfactory x 2**	**Good x 3**	**Very Good x 4**	**Score**	**Total**
Management Measures						
Safety meetings	1.01	2.01	3.02	4.03		
Safety plans and records	1.02	2.03	3.05	4.06		
Safety rewards/incentives	0.92	1.84	2.76	3.68		
Safety training	1.13	2.26	3.39	4.52		Subtotal 3
Project Nature						
Precautions over size of project	1.22	2.43	3.65	4.86		
Precautions over complexity of project	1.53	3.07	4.60	6.14		
Control over number of subcontractors	1.28	2.57	3.85	5.14		Subtotal 4
Individual Involvement						
Safety knowledge	2.05	4.10	6.16	8.21		
Safety attitude	2.22	4.45	6.67	8.90		Subtotal 5
Economic Investment						
Safety investment	1.72	3.44	5.16	6.88		
Formalities for workers' compensation insurance	2.11	4.21	6.32	8.43		Subtotal 6

Total Performance Score = Subtotal 1 + Subtotal 2 + Subtotal 3 + Subtotal 4 + Subtotal 5 + Subtotal 6

CONCLUSION

This paper provides a framework for evaluating safety management practices to improve safety performance in the Sri Lankan construction industry. To promote the objectivity of the framework, a range of key factors were identified through a comprehensive literature survey. Then, a Questionnaire Survey was conducted to establish the relative importance of each factor. Subsequently, the MS of each factor was analysed.

According to the responses of industry experts, all of the factors identified above (Figure 1) are very important in managing construction safety. None of the factors included in the questionnaire were rejected: all were identified as extremely important in managing construction safety. Overall, "management commitment" was found to be the most important main factor, while "complexity of project" was significant among sub factors. The main factor "economic investment" was less important, similar to the sub factor "safety rewards/incentives".

The developed Safety Management Framework is a more comprehensive framework for evaluating construction safety management. This framework provides a broad approach for measuring construction safety in Sri Lanka. Construction Safety Management is a measure that should be benchmarked to ensure continuous improvements. Deviations from the best practices of construction safety can be investigated and improved through this framework by identifying failures. Therefore, this framework should be used within the industry as an effective management tool for site safety and to overcome threats of hazards before an accident occurs.

Additionally, contractors' safety performances can be ranked according to their actual safety performances and be used in management decision-making. This proposed framework is a simple and direct tool for measuring contractors' safety performances as well. When contractors are classified according to the above scores, this framework could assist decision-makers in a variety of ways, including the determination of tendering opportunities, insurance premiums, awards or sanctions or benchmarking performances.

Having reviewed the different existing safety evaluation methods, a more comprehensive framework for evaluating construction safety management was developed. This framework provides a comprehensive analytical approach for major decision makers at both the organisational and project levels that is not found in any existing system in developing countries. This benchmarking system can be used at the tender stage for categorising the safety performances of contractors into different grades and for self-assessment to identify deviations from best practices and adopt necessary precautions.

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