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Original Article

Framework for Continuous Assessment and Improvement of Occupational Health and Safety Issues in Construction Companies

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ABSTRACT

Background: Construction industry is among the most hazardous industries, and needs a comprehensive and simple-to-administer tool to continuously assess and promote its health and safety performance.
Methods: Through the study of various standard systems (mainly Health, Safety, and Environment Management System; Occupational Health and Safety Assessment Series 180001; and British Standard, occupational health and safety management systems-Guide 8800), seven main elements were determined for the desired framework, and then, by reviewing literature, factors affecting these main elements were determined. The relative importance of each element and its related factors was calculated at organizational and project levels. The provided framework was then implemented in three construction companies, and results were compared together.
Results: The results of the study show that the relative importance of the main elements and their related factors differ between organizational and project levels: leadership and commitment are the most important elements at the organization level, whereas risk assessment and management are most important at the project level.
Conclusion: The present study demonstrated that the framework is easy to administer, and by interpreting the results, the main factors leading to the present condition of companies can be determined.

1. Introduction

Studies indicate that construction industry is among the most hazardous industries. According to the National Safety Council reports, 8,993 people died during 2003–2011 at construction workplaces in the United States, which was the highest number of fatalities among deaths occurring in all types of industries over this period of time. The same trend was observed in other countries as well. The situation is even worse in developing countries [1,2]. Working at a height, using different types of machines and equipment (for example, cranes, as one of the most commonly used machines in the construction industry, cause more than 50 deaths each year), dermal and inhalation exposure to different hazardous materials (such as silica dust and asbestos), inappropriate practices, awkward postures, employing workers from other countries with different languages and cultures, and the variable nature of working conditions pose a large number of unacceptable risks to all those who are dealing with construction projects, including workers, engineers, project managers, and so on [3,4]. Moreover, studies conducted in this field have revealed that a lack of attention to occupational health and safety (OH&S) issues results in irreversible costs, including costs associated with workplace accidents, reworking, delays, and loss of reputation of the organization and contractor [5].

As a consequence, in recent years, in addition to the triangle of time, cost, and quality, OH&S issues are increasingly being emphasized as an indicator for construction project success [6,7]. For these reasons, construction companies need an appropriate tool to continuously assess and improve their conditions with respect to OH&S.

Traditionally, accident or incident rates were used, but there is always an uncertainty about the accuracy of such reports; in

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addition, these indicators are retrospective in nature and provide information about what happened in the past. The safety performance evaluation (SPE) framework proposed by Ng et al [8] is more comprehensive, structured, and organized than previous tools. In this framework, seven and six main factors and their related subfactors had been determined at organizational and project levels, respectively; using them, two questionnaires were designed. The average score at these two levels would be considered as the final score of contractors. However, there are some problems with the SPE framework; for example, the safety performance of contractors, which is necessary to determine the extent of progression after the implementation of corrective actions, has not been quantified. Ai Lin Teo and Yean Yng Ling [9] provided another framework for assessing the performance of the safety management system at construction sites. Although the framework had some powerful features, it had not been used extensively due to the lack of a comprehensive, generally accepted, and standard basis. In fact, to achieve a continuous improvement in OH&S issues at a construction company, a combination of the aforementioned frameworks along with a well-established bedrock principle is needed.

Various models and standards are available that address OH&S assessment and improvement in various kinds of industries; Health, Safety, and Environment Management System (HSE-MS) and Occupational Health and Safety Assessment Series (OHSAS) 18001 are among the most popular ones. The HSE-MS, based on the plan–do–check–act methodology, is a cyclical process intending to achieve continuous improvement in health, safety, and environment at workplaces. A correctly implemented HSE-MS can result in declined accident rates, reduced number of injuries, lower waste generation, and more productivity. It is worth pointing out that various elements for HSE-MS may be expressed by different companies or guidelines; however, the key elements are the same (plan–do–check–act) [10,11]. The OHSAS 18001 is also a risk management system that is widely used to identify and manage unacceptable risks at workplaces. It is very similar to HSE-MS in terms of both basis and purpose. The British Standard, occupational health and safety management systems-Guide (BS 8800: 2004), is another useful tool to meet these objectives. Although the standard was basically developed for the United Kingdom, it has been adapted by other countries such as Finland.

Considering the strengths and weaknesses of previous frameworks, in this study, we aimed to provide a new framework that not only covers all drawbacks of the previous frameworks, but is also more simple and comprehensive.

2. Materials and methods

In total, eight safety- and health-related management systems, including OHSAS 180001, HSE-MS, ISO 14001 (Environmental Management System), ISO 50001 (Energy Management), ISO/IEC 27001 (Information Security Management), ISO 20121 (Sustainable Events Management), BS 8800, and AS/NZS 4801 (Australia Standard of Occupational Health and Safety Management Systems), were reviewed to define a framework for evaluating OH&S performance of construction companies. Three of them, HSE-MS, OHSAS 180001, and BS 8800, were singled out as the framework inputs. These systems have widely been used and also are easy to administer. Based on them, seven main elements—"leadership and commitment," "policy and strategic objectives," "organization, resources, and documentation," "risk assessment and management," "planning," "implementation and monitoring," and "measuring performance, auditing, and reviewing"—were selected. By reviewing the literature, factors that would affect these seven elements at two levels (organization and project) were discerned [12–15]. The study was carried out in four steps. Questionnaire designing was the first step in which two sets of questionnaires were designed using the main elements and related factors, which were identified in the first part of the study. The main elements were scored on a seven point scale, ranging from 1 (very important) to 7 (less important), whereas a five-point scale ranging from 1 (very important) to 5 (less important) was used to score their related factors. The designed questionnaire was then sent out to 15 respondents, including university professors and PhD candidates, who were experts in OH&S issues. The consensus was achieved in the second round. The questionnaire reliability was determined using kappa coefficient. After that, the finalized questionnaires were sent to 75 people, including employers, contractors, and health and safety experts, who were involved in constructional affairs in some way. They were asked to assess the importance of each element and its related factors.

Calculation of the relative importance of the elements and their related factors was the second step of the study. The relative importance was computed with the method used by Assaf et al [16] as follows:

For the elements, calculations were performed based on mean ranking (MR):

$$\mathrm{MR} = \frac{\sum f \times r}{N} (1 \leq \mathrm{MR} \leq 7) \qquad [1]$$

$$\mathrm{RI}_j = \frac{\sum_{i=1}^{N} \mathrm{MR}_i}{\mathrm{MR}_j} \qquad [2]$$

In Equation 1, r is ranking and f is the frequency for that ranking, and N is the total number of responses; in Equation 2, RI_j is the relative importance of the jth element.

For related factors, mean scoring (MS) was used to calculate RI:

$$\mathrm{MS} = \frac{\sum f \times s}{N} (1 \leq \mathrm{MS} \leq 5) \qquad [3]$$

$$\mathrm{RI}_{ij} = \frac{\mathrm{MS}_{ij}}{\sum_{i=1}^{N} \mathrm{MS}_{ij}} \qquad [4]$$

In Equation 3, s is the score of each factor, f the frequency of each rating, and N the total number of responses to each factor; in Equation 4, RI_{ij} is the relative importance of the ith factor related to the jth element and MS_{ij} is the mean score of the ith factor related to the jth element.

In the third step, the performance index was calculated; elements and their factors and also the true performance of contractors with respect to OH&S issues were combined in one index, using the following equation:

$$\mathrm{PI}_{ij} = \frac{\mathrm{PW} \times \mathrm{RI}_{ij(\mathrm{factor})} \times \mathrm{RI}_{j(\mathrm{element})}}{5} \times 100 \qquad [5]$$

Here PI_{ij} is the performance index of the ith factor related to the jth element and PW the score of true performance of contractors (1 = very poor, 2 = poor, 3 = normal, 4 = good, and 5 = very good). In the fourth step, contractor performance was quantified. The summation of all PI_{ij} scores is equal to the contractor total score (Equation 6). Table 1 shows a schematic of the final version of the framework that we were intended to achieve.

$$\mathrm{TPI} = \sum_{j=1}^{7} \sum_{i=1}^{n} \mathrm{PI}_{ij} \qquad [6]$$

Here, TPI is the total performance index for each contractor. According to TPI, contractor's performance was classified into five