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Construction safety factors assessment through Frequency Adjusted Importance Index

Murat Gunduz*, Bappy Ahsan

Dept. of Civil Engineering, Qatar University, PO Box: 2713, Doha, Qatar

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ABSTRACT

The construction industry is plagued by numerous accidents and fatalities due to improper implementation of safety measures. Globally, researchers have concluded that the construction environment is the most hazardous when compared to other labor enforced industries. Construction is a temporary project-based industry, however, the injuries sustained to workers and stakeholders involved are permanent. Rigorous measures need to be taken to ensure a safe atmosphere on-site and laws governing implementation of safety management programs need to be enforced internationally. The objective of this paper is to identify what is perceived to be the most influential safety attributes affecting the construction industry. After a review of the literature, a list of 40 safety attributes was produced and presented in a survey. The survey was distributed online and sent to various experts in the construction industry. 238 complete responses were received and analyzed by Frequency Adjusted Importance Index, Spearman's Rank Correlation, T-Test. As a result, "use of PPE (Personal Protective Equipment) and following safety rules and procedures," and "providing safety trainings, campaigns and awareness to employees by contractor, "were ranked as the most important safety attributes. The main contribution of this study can be summarized as ranking the safety attributes considering both their importance and frequencies as perceived by various groups of industry professionals and identification of influential attributes affecting construction safety which have significant level of agreement among various groups in the construction industry.

1. Introduction

The construction industry is well associated with a high number of accidents which occurs worldwide; as a result, the industry needs to employ stringent measures to minimize the number of incidents. Since safety in construction is a highly complex phenomenon, many factors need to be considered prior to implementation of these measures. Inadequate safety measures have an adverse effect on all individuals involved in a construction project as there is an investment made financially and physically in terms of workers. A lot of research has been performed on identifying safety attributes to improve the overall safety culture within an organization and project site. This study differs from past studies by compiling relevant safety attributes by an extensive literature review and analyzing the collected data through a survey by adjusting the importance of each attribute by their frequency. Adjusting with the frequency presents more reliable and realistic ranking of attributes.

Safety management plays a major role in the success of the projects in order to minimize additional costs and delays. The objective of this paper is to study and compare the various attributes linked to safety management, as perceived by experts, in the construction industry.

2. Literature review

Literature on construction safety was analyzed to capture factors that affect safety at the construction site and the measures that can be taken to mitigate or reduce unsafe conditions. Yu et al., 2014 has summarized forty safety characteristics into four key factors by means of factor analysis which greatly influences the safety management of metro construction in China. To gather data, the researchers distributed a survey questionnaire amongst 120 engineers involved in 38 metro construction projects from five

* Corresponding author.
E-mail addresses: mgunduz@qu.edu.qa (M. Gunduz), 200600341@student.qu.edu.qa (B. Ahsan).

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different Chinese cities to understand the perceptions of the stakeholders through importance rating. There are many other studies carried out in the literature to capture factors that affect safety (Guo and Yiu, 2015; Varnas et al. 2010; Gunduz et al., 2017; Jannadi and Bu-Khamsin, 2002; Hu et al., 2011; Dejus and Viteikiene, 2004; Ng et al., 2005; Fung et al., 2005; Gunduz et al., 2018; Shen et al., 2015; Gunduz and ve Simsek, 2007; Abdelhamid and Everett, 2000; Mohamed, 2002; Terwel and Jansen, 2015; Gunduz et al., 2017; Fang et al., 2004; Maskeliūnaitė and Sivilevičius, 2012; Yu et al., 2014; Hsiao and Simeonov, 2001).

After the extensive literate review, 40 factors that have significant effect on construction safety were captured and listed in Table 1. The table was developed by the help of construction safety experts with high experience in this field. Table 1 also classifies them into categories such as: educational, managerial, health, etc. The categories were developed by their nature of formation after compiling all relevant safety attributes by an extensive literature review. For example, management related attributes were compiled under Category: Managerial, etc.

A survey was then formed to help identify the most critical safety factors in the construction industry. These safety factors were developed according to the literature review results. During the pilot study, the participants were asked to provide additional factors that were not on the list. Afterwards, the final form of survey was finalized. The main contribution of this study can be summarized as ranking the safety attributes considering both their importance and frequencies as perceived by various groups of industry professionals and identification of influential attributes affecting construction safety which have significant level of agreement among various groups in the construction industry. This study differs from other studies in the literature by the introduction of the "frequency" dimension. This way the safety factors were prioritized in a more realistic manner considering how often they occur in construction sites. It also compiled the most significant safety factors from literature and analyzed all these factors together with the "frequency dimension" as perceived by various groups of industry professionals and identification of influential attributes affecting construction safety which have significant level of agreement among various groups in the construction industry.

3. Methodology

This study has adopted both qualitative and quantitative research techniques. Following an initial establishment of a draft list of safety attributes collected from qualitative literature review; discussions and recommendations from industry experts were taken into account to revise it further. Altogether, a list of 40 safety attributes was compiled. To achieve the objective of identifying the influencing safety attributes affecting the construction industry, a survey was prepared. The first section of the survey was intended to obtain background information on the participants. This section requested the respondent to fill in appropriate information relating to his/her location, organization type, industry, job designation, total years of work experience and years of experience in construction safety. This section would help in categorizing the respondents into different groups for the purpose of comparisons. In the second section, the respondents were requested to evaluate the "importance" (the impact on safety in construction project) and "frequency" (How often the attribute is implemented or considered) on a 5 point Likert Scale (1 = Very Low, 2 = Low, 3 = Moderate, 4 = high, 5 = Very High). The compiled 40 safety factors can be seen in Table 2.

For an example, for the first safety attribute of "Selection of safe contractors with contractual safety requirements", the respondent was asked to evaluate the:

- Importance: What is the impact of "selection of safe contractors with contractual safety requirements" on safety in construction project?
- Frequency: How often is "selection of safe contractors with contractual safety requirements" considered or implemented for safety in construction project?

The term frequency expresses the application frequency of the safety factor (consideration if not applied) of the survey respondent. The frequency value at a first glance is the how often that factor is implemented in the construction site. If it is or cannot be implemented in the construction site, then the frequency term refers to the consideration of the survey respondent.

The survey was sent to safety professionals in the construction industry around the world. A total of 238 completed surveys were received. The survey collected data with the help of a professional website.

Data analysis was performed based on statistical analyses such as Frequency Adjusted Importance Index, Spearman's Rank Correlation and T-Test. Attributes were ranked as perceived by various groups of industry professionals.

The Relative Importance Index (RII) was chosen to assess the importance of each safety attribute based on scores from the survey responses. The five-point Likert Scale was applied to rate the importance of the attributes in terms of importance and frequency. The safety attributes were ranked based on the values of computed relative importance index, frequency index and frequency adjusted importance index.

The Frequency Adjusted Importance Index (FAII) is a similar yet innovative ranking approach used by (Yahya, 2014) to rank the project success factors in the Middle East & UAE. It was also used by (Marzouk and El-Rasas, 2014) to identify and rank top 10 factors associated with delays in construction of civil engineering projects in Egypt. This technique considers the importance and the frequency in its formula. This ranking approach was also adopted in this research to rank the safety attributes. In order to find the FAII, the Frequency index (FI) and the Relative Importance Index (RII) need to be calculated. The frequency of the attributes was also measured using the Five-point Likert Scale. Then the values will be calculated based on the following formula:

$$FAII = (RII)\,(\%) * (FI)\,(\%), \tag{1}$$

Where;

$$(RII)(\%) = (\sum W\ (\text{importance}) / A^{*}N)^{*}100, \tag{2}$$

$$(FI)(\%) = (\sum W\ (\text{frequency}) / A^{*}N)^{*}100, \tag{3}$$

Where:

W = weight given to each factor by the respondents (1–5).
A = the highest weight (in this case is 5).
N = total number of respondents

FAII provided better ranking results due to its combination of effects of importance and frequency in one formula.

Ranking of the influential safety attributes was also performed based on the views of experts from different backgrounds with the statistical tool, Spearman's rank correlation coefficient, for example, it was used to check the correlation between the importance and frequency indexes for the overall survey. Spearman's rank correlation is a non-parametric test. It does not require the normality of the distribution or the homogeneity of the data which is considered as a big advantage over other approaches. The