A New Approach for the Evaluation of Workshops of Tall Buildings in Mashhad using HSE Approach (Case Study: Construction Projects)

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1. Introduction

New technologies and the growth of construction industry have increased the probability of accidents and errors in the manufacturing process. Therefore, the protection of human resources, equipment and environment are priorities of the construction industry. For evaluating the health (H), safety (S), and environment (E) concerns in construction projects, HSE method is used. This is a systematic procedure which is used for protection of capital, work force and environmental towards the risks arise from unpredictable events in construction projects. The HSE method is concerned with preserving and protecting human resources in the workplace. In other words, the HSE method is a professional attempt to prevent catastrophic losses. There are several methods to evaluate the health, safety, and environment of construction site. These methods use questionnaire to collect data. Questionnaires are categorized into several parts including safety legislation, industrial hygiene, workplace violence, hazardous materials, safety management, falling danger, etc. Also, there are several approaches to evaluate questionnaires such as SPSS, MATRIX analysis, SWOT matrix, and other simulation methods like Monte Carlo and Fuzzy techniques.

Considering and evaluating the health, safety and environmental subjects in construction projects are the goal of this paper. To achieve this purpose, HSE method is used for evaluating construction projects in Mashhad city. In this way, the HSE factors are identified. Eight questionnaires were designed based on HSE planning, site safety, welding, supporting structure, fire station, electricity safety, hygiene, and crane. Then, according to the questionnaires a performance function is proposed.

2. Data Collection and Analysis

To evaluate HSE in high building construction project of Mashhad, a questionnaire was designed. The necessary data was collected according to the HSE experts, project managers and supervisors of workshops comments. Then, the evaluation of questionnaires and validation of proposed performance function were carried out by SWOT matrix and Monte Carlo simulation. The name of projects, commentator, and employment history of commentators are given in table 1.

Table 1. Name of projects, commentator and employment history

Project name	Commentator	Employment history (year)
Eleman tower	Project manager	17
Yas Residential tower (Ershad Blvd)	HSE Expert	10
	Professional health expert	12
Armitazh tower	Architectural supervisor	12
	HSE supervisor	10
Yas residential and commercial tower (Janbaz Blvd)	Site manager	15
	Site manager	12
	HSE Expert	10
	HSE Expert	10

According to Table 1, number of available data is very limited. Therefore, to increase sample data, the Monte Carlo simulation procedure was used. Monte Carlo simulation is utilized to generate the sample data based on the real data properties such as mean, standard deviation, and probability density function. Therefore, the generated data have suitable validity and accuracy. Moreover, for evaluating the questionnaires, SWOT matrix method was used. This method can classify and compare different factors with assigning scores. The assigned score arises from the probability of occurrence of factors in projects. Finally, the proposed performance function runs based on the assigned score.

3. Proposed Performance Function and Numerical Results

In order to evaluate the health, safety and environment (HSE) in construction project a new model is proposed. The proposed model is defined as follows:

$$SF=h\times H+s\times S+ss\times SS+f\times F+p\times P+e\times E+w\times W+c\times C \quad (1)$$

where h, s, ss, f, p, e, w and c are weighting coefficients of hygiene, site safety, support structure, fire station, HSE planning, electricity safety, welding and crane, respectively. These coefficients are considered to increase the model efficiency and accuracy. The introduced coefficients are based on the percent of importance of designed questionnaires.

It should be mentioned that values of these coefficients are between 0 and 100. The sum of all the weights must equal to 1. Therefore, the coefficients of the factors depend on how they are done in the project. Also, factors of each questionnaire are assigned by rate 1 to 4 according to their importance in project.

SWOT MATRIX procedure is used for evaluating the

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proposed model. According to the SWOT MATRIX analysis, if the total point of questionnaire's factors (sum of factor's score) is equal or greater than 2.5 point, the questionnaire subject has a suitable status in considered projects. This point is calculated by multiplying the weighting factors. Finally, the point of questionnaire will be obtained by adding the factor's point. If the questionnaire obtains the least point (2.5), the answer of proposed performance function will be equal to 20;

$$SF_{all}=h\times H+s\times S+ss\times SS+f\times F+p\times P+e\times E+w\times W+c\times C=20 \quad (2)$$

As a result, the HSE condition of project obtains by comparing its SF with $SF_{all.}$ In this way for increasing the sample data, the Monte Carlo simulation procedure is used. This procedure can simulate the project condition and consider the possible events.

4. Conclusion

In this study, a new performance function for evaluating health, safety and environment (HSE) subjects in construction projects is proposed. This process is carried out by designing questionnaires based on nine categories. First, the designed questionnaire was distributed between construction experts. To evaluate the questionnaire, the SOWT matrix procedure is used. To increase the sample data of construction projects, the Monte Carlo simulation procedure was used. the evaluation the HSE subject in construction projects was done by generating 100'000 samples for each questionnaire.

For rating and comparing the designed questionnaires and evaluating the HSE subjects in construction projects, the simulation process performed two times. First, only one questionnaire (parameter) was considered as a variable value in each process of simulation. Then, all questionnaires (parameters) were simulated in the proposed performance function.
Figure 1 shows the probability of occurrence for each parameter in tall buildings.

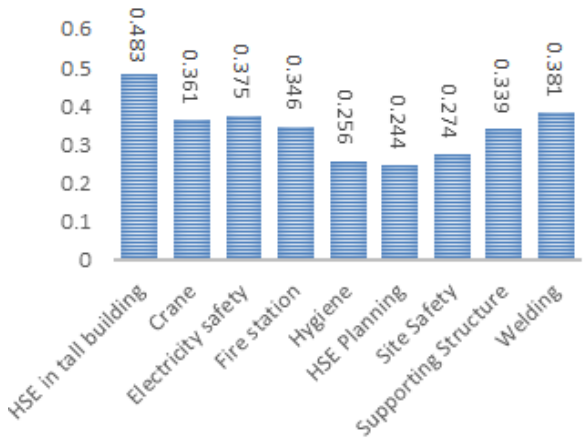

Figure 1. The probability of occurrence for different parameter in tall buildings

According to the Figure 1, the HSE planning and welding parameters have the lowest and highest risk in tall building construction projects, respectively. Also, the risk of the HSE subject in tall building projects is about 50%.

Finally, the proposed performance function can be used for evaluating the HSE issue in different construction projects. In this way, the important parameters must be identified, and then similar process, described here, can be performed.