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Significant Factors Affecting Safety Program Performance of Construction Firms in Iran

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Abstract

Globally, the construction industry is still considered as one of the most hazardous industries. According to the statistics proportion of accidents on construction sites are relatively high in Iran and after steel industry the highest accident rate is related to construction sector. Considering this situation, this paper aims to determine the important safety program factors, which influence the implementation of safety programs perceived by construction contractors. A list of 21 safety program sub factors categorized in 5 main clusters was determined to calculate the rank and importance of each factor. The date collection processes 61 questionnaires from grade one and 44 from grade two construction firms. It is found that the management commitment was ranked as the most important factor as compared to other main safety program factors. The most influential sub factors by all firms were found sufficient resource allocation to safety, high standard safety policies and personnel and management responsibilities definition regarding to project safety. On the other hand, Drug test, job hazard identifications and Workers behavior observation process are perceived as less important in influencing implementation of successful safety program in construction projects.

Keywords: Safety Program, Construction Site, Safety Factors, Iran

1 Introduction

The construction industry is known as one of the dangerous industries in the world with wide range of accidents, injuries, fatalities and lost work time. Hence, implementation of safety and health in construction sites is a necessity [1].

In a market-driven community, it is usual that stakeholders concentrate particularly on time, cost and quality aspects of the projects and safety is not conidered as a main concern[2]. While, Construction accidents cause many human tragedies, and led to direct and indirect expenses. Direct Expenses include medical costs and workers' compensation insurance. Indirect expenses contain delays and disruptions in construction processes, workers motivation diminishing and adverse effects on reputation of the construction firms [3, 4].

Since in developing countries construction safety and health regulations are not adequetely powerfull, safety rules barely exist and they are not often applicable properly [5]. According to [6], proportion of accidents on construction sites are relatively high in Iran and after steel industry the highest accident rate is related to construction sector. Hence, that the rate of accident reports and statistics at construction sectors in Iran signal a need for more attention.

The results of this study among 47 construction firms in Iran illustrate resource allocation to safety exist among a few number of firms. Only 55.2 % of firms allocated separate fund to safety; about 80% did not implement safety training program; 30% did not hired full-time safety staff at construction sites and 48% did not held safety committee meeting at all. This comes to the conclusion that the idea of safety barely exists among construction contractors.

Regarding to this situation, the aim of this paper is to determine the significant safety factors, which influence the implementation of safety programs. By capturing contractor's point of view on the factors affect the safety performance in construction sites, this research tries to shed a light for management to proactively implement an effective safety program at construction sites. The authors also believe that the final results can be used to select the most effective and strategic elements of safety programs, especially in developing countries like Iran. Currently, safety is a constitution that must be improved by limited recourses. Additionally, at the beginning stage of safety program implementations, it may be difficult for small and medium construction size firms to implement all of safety program elements simultaneously. Hence, prioritizing these elements would enable initiation the safety program in a practical manner.

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2- Safety Program Factor

Safety program is a proactive procedure to enhance safety performance at construction sites [7]. It has to be safety programs which reduce accident and injury rates by preparing a safe working condition for employees and creating safety culture within the organization [2].

There is a wide range of safety progarams and practices that can be applied to improve safety perfomance [8] and there are various indicators to choose and design a construction safety program [9]. It was found, that there are over 300 various injury prevention techniques for construction projects, such as safety audit, job hazard analyses, emergency response planning and many others [10]. In another study by Aksorn and Hadikusumo (2008), revealed 16 critical success factors (CSFs) related to construction safety programs in Thai and highlighted Management Support as the most dominant factor [11].

The Construction Industry Institute (CII) also identified eight necessary element of a successful construction safety program [12]: commitment of management to safety, , pre-task planning, employee involvement, staffing for safety, safety training, , safety incentives, accident investigations, substance abuse programs and subcontractor management.

Thomas Ng (2005) proposed an evaluation framwork to continuously review and mointor safety perfromance of contractors [2]. To develop a comprehensive framework, various safety performance evaluation elements were identified divided to 13 organization and 18 project level fators were pertinent to project level. A framework to continuously monitor and control safety and health at construction sites proposed by (Mahmoudi, Ghasemi et al. 2014) which includes 7 factor and 120 sub factors that influence safety in construction projects. Hinze [8] presented 104 potential safety strategies at the first step of his study to cover all types of practices in construction firms with respect to injury prevention.

Proper selection of leading indicators is critical to success of the contractor safety program. Some firms consider many means of enhancing safety performance and select the one that is regarded as the most promising or cost effective. Each implemented practice will result in a cost, which involves initial development, tailoring the strategy to company operations and ongoing implementation. Also details of program implementation must be drafted, supervisors and workers must be trained about the new practices and the practices must then be monitored to evaluate their success [8].

Since most firms consider limited budget for safety programs, contractors have to choose limited subset of the available elements [9]. [13] revealed that most contractors select safety program elements in an informal fashion with little considering of its relative effectiveness. Also, most contractors were said to rely on intuition and word of mouth when designing site-specific safety programs. This situation raised a concern of: "what are the most appropriate programs to improve and control health and safety in construction projects?"

To respond the above question and determine the dominant of construction safety factors, after a comprehensive review of literature, the authors identified 21 independent safety program factors, which are further categorized into 5 clusters. These factors are summarized in Table 1.

3- Research Methodology

To determine the safety program factors, an extensive literature search carried out in publications. It identified 21 independent safety program factors, which categorized in 5 clusters. These factors are summarized in Table 1. The method of collecting primary data in this study was questionnaire survey which divided in two main parts, the first part was on demographic information of respondents and the second part ask their opinions about the impact of each factors and sub factors on the implementation of safety and health during construction projects in Iran. Preferred method for the second part of questionnaire was Likert scale, which is a common method for questionnaire type of survey, as it gives an expanded option of alternatives for the respondents. Before distribution of main questionnaire, a Pilot questionnaire was conducted between 12 experts, included eight safety managers and four academic researchers in construction management field, to check the feasibility and appropriateness of the factors, sub factors and general format of questionnaire. Following the pilot study, the Alpha Cronbach reliability test was utilized to check the groupings appropriateness of the of 5 main factors extracted. The value of 0.7 is generally accepted as the minimum desired value of the coefficient [47]. As demonstrated in Table 4, the reliability coefficients rate were between 0.75 and 0.90, therefore all were considered acceptable. The questionnaire distributed between construction firms obtained grade one and two in Iran.

To reach an appropriate sample size for quantitative survey, utilizing Creative Research System software (www.surveysystem.com/sscalc.htm), the sample size was calculated considering 95% Confidence level and 10% Confidence Interval. The number of sample size calculated with the software was 96. Considering 30% as dropout, 32 sample size was added to this number and at the end total number of 138 questionnaire were distributed between construction firms obtained grade one and two in Iran. Firms grade one have the opportunity to conduct numerous projects simultaneously and also they are allowed to attend in construction bids with higher prices compared to firms with grade two. These numbers and prices along with other differences are exactly specified in a code for different field of works.

A total of 138 questionnaires were distributed among respondents, where 93 questionnaires were distributed by hand and 45 were distributed through e-mail. Of all the 138 questionnaires that were sent out, 111 contractors responded to the survey (81% of response rate).

Among these 111 responses, 6 responses were recognized invalid and at the end 105 questionnaires (76% of total questionnaires) were considered as reliable data for this study. As demographic statistics illustrated in Table 2, 44 of the received questionnaires were related to grade one firms and the rest of 61 were for grade two firms. Since the study results rely on responses of sample, the election of respondents was regarded to be of utmost importance [48].

Table 1. Main Factors and Sub-factors of construction safety programs

Main Factors	Sub-Factors	Description	Researchers
Employee involvement	Workers Stop work authority	Throughout project execution, Employees should be empowered with stop authority for safety concerns to reduce accident possibility and correct them before injury happens.	[10, 14]
	Safety committee	A committee made up of supervisors, workers and management representatives with the goal of addressing safety and health on the worksite through activates such as conducting regular meeting, inspections and etc.	[2, 9-11, 15, 16]
	Communication	An effective communication between management crew and employees can help rapid reporting and responding to unsafe working practices or hazardous conditions.	[11, 15-20]
	Incentive	Safety incentive is one of proactive techniques utilized by management to motivate employees to work safely. The incentives can be financial and nonfinancial awards to encourage employees to be involved in safety programs.	[10, 14, 21-25]
Inspection	Site safety Inspections	The goal of safety Inspection is to assess physical working condition of site to identify uncontrolled hazardous exposures to workers and violation of safety standards or policies.	[10, 11, 19, 26, 27]
	Job Hazard identification	The purpose is checking all activities and materials related to construction procedures to identify potential hazardous that may cause accidents or injuries.	[3, 9-11, 28]
	Workers behavior observation process	Observing workers by another worker or any person and monitoring of human errors on construction sites can be a proactive way to improve workers safety performance	[11, 14, 25, 26]
	Accident investigations	It involves recording and reporting the information and specifics of all accidents or near misses to facilitate analyses of accident data to identify the errors and apply corrective actions.	[3, 9, 14, 23, 25, 27, 29, 30]
Management Commitment	Management and employees responsibilities definition	Determine clear safety responsibility and accountability among management and project personnel to carry out appropriate actions.	[10, 14, 27, 31-33]
	Sufficient resource allocation to safety	To goals of safety programs cannot be reached unless Management consider and allocate sufficient resources including staff, money, time, machines and tools to accomplish construction procedures.	[11, 16, 19, 34, 35]
	Safety program evaluation (Audit)	Safety auditing is an organization safety evaluation procedure to determine its success in meeting set out goals and objectives. It involves documenting the process, gathering data and information, comparing data with set criteria and objectively deciding whether the result conforms to the criteria.	[3, 10, 11, 14, 16, 25, 36]
	Comprehensive and High standard safety Policies	Safety policy demonstrate the definition of organization in prioritizing safety in workplace, having high characteristics standard policies in accordance with relevant legislations can improve management and employees attitudes towards construction safety performance.	[2, 15, 19, 23, 27, 37]
Organizational structure	Subcontractor management	The subcontractors must be involved as essential members of safety management procedures to ensure general contractor and/or owner that they follow project safety requirement and regulations.	[10-12, 14, 25]
	Adequate safety supervisors	Safety supervisors play a vital role in ensuring safety at workplace and subsequently, The ratio of the number of workers to safety supervisors must be considered.	[5, 10, 19, 38]
	Assign Competent employees for all high hazard tasks	Assigning the right employee on the right task defined as placing competent person who is capable of identifying existing and predictable hazards in the work environment.	[10, 11, 25, 39]
Safety prevention and control system	Training	A vital factor of a successful safety program is to periodically train and educate all employees to enhance their knowledge and skill about safety at work.	[3, 7, 10, 14, 39, 40]
	Housekeeping	Housekeeping procedure defined as keeping workplace clean and orderly through Appropriate storage and removing of waste materials used in construction sites.	[10, 14, 36]
	Emergency response planning and preparation	It defined as creation of a preparedness plan helps to minimize the human suffering and economic losses in the case of a serious incident such as a fatality or an incident involving multiple serious injuries.	[9, 10, 19, 25, 41]
	Drug test	Randomly drug test of the employees led to identify and prevent them from substance abuse in workplace.	[10, 14, 42]
	Pre-Task planning for Safety	Meetings that are held just before the work commence, like mini-training, to analyze each task and Identify potential health & safety hazards of the tasks.	[10, 14, 43, 44]
	Personal Protective Equipment (PPE) and plant maintenance	Regular checking and maintenance plant and protective equipment such as helmet, safety eyewear and reflective jackets which is intended to protect employees against potential hazards.	[2, 3, 10, 15, 19, 25, 45, 46]

Hence, respondents were expected to have adequate work experience in construction industry, be currently or recent directly involved in construction safety management and have an extensive knowledge about safety programs. The relative importance of each factor was calculated based on the following equation [49]:

$$I = \frac{\sum_{i=1}^{5} X_i Y_i}{\sum_{i=1}^{5} X_i} \quad \text{Eq. 1}$$

where, i= Response category index; whereby 1=not important, 2= slightly important, 3= moderately important, 4= important, 5= very important, Y_i= Weight assigned to the response=1, 2,3,4 and 5 respectively and X_i= Frequency of the response given as percentage of total response for each cases. The Index (I) had a range from 1 to 5; the higher value of index implies the higher degree of importance of each factor. The computed index was then used to rank the main factors and sub factor as perceived by the respondents. The obtained raw data were then used as input and analyzed with the statistical analysis software (SPSS). Then to rank the important

factors according to the average scores the analysis were conducted.

4- Results and Discussion

Table 3 demonstrates the detailed breakdown of the mean rankings of 21 safety program sub factors based on the responses of company's grade one and two. According to the final results, the most effective safety program sub factors identified by grade one firms were Sufficient resource allocation to safety, Personnel and management responsibilities definition regarding to project safety, and Comprehensive and high standard safety policies with the means value of 4.71, 4.83 and 4.49 respectively. While, the grade two firms recognized comprehensive and high standard safety policies, sufficient resource allocation to safety and assign a competent employee for all high hazard tasks with the means value of 4.56, 4.50 and 4.34 as impressive sub factors. Result also show, the least important safety sub factors recognized by all firms were Job hazard identification 4.31, Drug test 3.34 and Workers behavior observation process 3.37.

In overall, the highest ranking by respondents of all firms was sufficient resource allocation to safety, which therefore regarded as an extremely influential factor to implement safety at construction sites. Subsequently, Comprehensive and high standard safety policies and Personnel and management responsibilities definition were ranked as the second and third sub factors with high level of impression on effective safety program implementation.

Therefore, it was concluded that the similarity of rankings between firms' grade one and two respondents were strongly significant. This suggested that there is a general consensus on the rankings of the influence of the success factors.

The Analysis of the main safety program factors and Cronbach's alpha reliability test for each factor are demonstrated in Table 4. According to results, all respondents believed Management Commitment to safety is the most impressive factor influence addressing safety by both firms grade one and two. Following that, Safety Prevention and Control System, Organizational Structure and Employee Involvement ranked as second, third and fourth important safety program factors respectively. Also, all respondents from both firms grade one and two believed Inspection is the least effective factor by ranking it in the fifth place.

5- Conclusions

The aim of this paper is to determine the significant safety factors, which influence the implementation of safety programs in Iran. A list of 21 safety program sub factors categorized in 5 main clusters was determined from extensive body of knowledge to calculate the rank and importance of each factor. The date collection processes 61 questionnaires from grade one and 44 from grade two construction firms.

According to the final results, the management commitment was ranked as the most important factor as firmsared to other main safety program factors. Subsequently, the most influential sub factors by all firms were found sufficient resource allocation to safety, high standard safety policies and personnel and management responsibilities definition regarding to project safety. On the other hand, Drug test, job hazard identifications and Workers behavior observation process are perceived as less important in influencing implementation of successful safety program in construction projects.

Based on Table 3, the data collected from this study can be used as a guide for selection of construction safety programs. This information is helpful in prioritizing important factors when a comprehensive safety program has to be developed and ensure that construction firms are not wasting their resources on ineffective safety programs.

Table 2. Demographic analyses

Demographic criteria	**Firms grade 1**		**Firms grade 2**	
	Frequency	**%**	**Frequency**	**%**
Gender				
Male	61	100	44	100
Education				
BSc	16	26.2	32.0	72.7
Master	34	55.7	9.0	20.5
PhD	11	18.0	3.0	6.8
Years of working experience				
Between 1 to 5 years	5	8.2	3	6.8
Between 6 to 10 years	6	9.8	7	15.9
Between 11 to 15 years	14	23.0	6	13.6
Between 16 to 20 years	16	26.2	17	38.6
21 years and more	20	32.8	11	25.0
Field of specialization				
Supervisor	24	39.3	19	43.2
Safety & health manager	9	14.8	11	25.0
Project engineer	17	27.9	10	22.7
Designer	6	9.8	2	4.5
Top management	5	8.2	2	4.5

Table 3. Mean values and rankings of safety program sub-factors

Safety program Sub factors	Firms grade 1		Firms grade 2		All Firms	
	Mean	Rank	Mean	Rank	Mean	Rank
1.1 Management & employees responsibilities definition	4.71	2	4.09	5	4.4	3
1.2 Sufficient resource allocation to safety	4.83	1	4.5	2	4.67	1
1.3 Safety program evaluation (Audit)	4.39	4	4.16	4	4.28	4
1.4 Comprehensive & high standard safety policies	4.49	3	4.56	1	4.53	2
2.1 Training	3.93	9	3.78	12	3.86	12
2.2 Housekeeping	3.76	12	3.97	7	3.87	11
2.3 Emergency response planning & preparation	3.95	8	3.84	10	3.9	8
2-4 Drug test	3.34	18	3.34	19	3.34	20
2.5 Pre-task planning for safety	3.95	8	3.81	11	3.88	9
2.6 Personal Protective Equipment (PPE) & plant maintenance	4.12	5	4.06	6	4.09	6
3.1 Subcontractor management	3.51	16	3.72	14	3.62	16
3.2 Adequate safety supervisors	3.8	11	3.91	9	3.86	10
3.3 Assign competent employee for all high hazard tasks	4.05	6	4.34	3	4.2	5
4.1 Workers stop work authority	4	7	3.94	8	3.97	7
4.2 Safety committee	3.9	10	3.75	13	3.83	13
4.3 Communication	3.73	13	3.84	10	3.79	14
4.4 Incentive	3.61	15	3.62	16	3.62	17
5.1 Site safety inspections	3.66	14	3.66	15	3.66	15
52 Job hazard identification	3.27	20	3.34	19	3.31	21
5.3 Workers behavior observation process	3.29	19	3.44	18	3.37	19
5.4 Accident investigations	3.46	17	3.47	17	3.47	18

Table 4. Mean and Cronbach's values for main safety program factors

	Main safety program factors	Firms grade 1		Firms grade 2		All Firms Mean
		Mean	Cronbach's Alpha	Mean	Cronbach's Alpha	
1	Management Commitment	4.78	0.777	4.59	0.793	4.69
2	Safety Prevention & Control System	4.27	0.887	4.31	0.853	4.29
3	Organizational Structure	4.12	0.874	4.22	0.866	4.17
4	Employee Involvement	4.07	0.868	4	0.877	4.04
5	Inspection	3.54	0.905	3.56	0.904	3.55

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