

Factors Affecting the Construction Site Safety – A Review of Literature

Abstract— The scientific literature regarding factors affecting the construction site safety and safety management has been reviewed. The purpose of this study is to identify the most critical or most frequent safety factors by reviewing the articles from across the globe related to the various safety factors that affects the site safety in the construction industry. Furthermore results has been summarized in a way that can help the researcher to quickly identify the most frequent safety factors. By reviewing this study, researchers can identify the most frequent safety factors which affects the construction site safety which can help in making efficient safety management system. Furthermore performance of the construction site safety also can be improved by controlling various factors summarised in this study.

Key words: Safety Management, Factors Affecting Safety, Review, Most Frequent, Construction

INTRODUCTION

During last decade Indian construction industry has seen a rapid growth. A research regarding various factors that affects the safety in construction needs to carry out in order to identify the most critical & frequent factors and to manage the construction sites affectively. Construction sites are generally complex and sometimes unsafe. They are complex because of extensive use of sophisticated plants, equipment, modern methods of construction, multidisciplinary and multitasked aspects of its project workforce. Construction sites are still one of the most dangerous workplaces because of high incidence of accidents. [16]

REVIEW APPROACH

This study focused on collecting data from the secondary data collection approach. Vast number of literature articles related to the safety management and various factors that affects the performance of the construction site safety has been reviewed from all across the globe.

FINDINGS & DISCUSSIONS

In this section, various factors which has been found by reviewing different literature articles are brought to the surface. Total 19 numbers of literature articles has been reviewed in sub-section A. In the sub-section B, analysis of the reviewed articles has been carried out to formulate the conclusion of the study.

A. Review of Literature Articles

NING De-chun, WANG Jian-ping, NI Guo-dong performed Fuzzy Decision Making Method to determine the most affecting factors to the construction safety management. The major findings from their study are as follow. They conclude that the hazards which already identified by

different identification methods must be eliminated, which is corresponding to the factor 'Eradication of hazards'. They derived the factor 'Safety Budget' and quoted that should not be compromised in the quest of minimum time. They also quoted that project managers have to take active role in implementing safety training program. Which governs the factor, 'Safety Training'. Furthermore as the project managers do afraid of the penalties from the safety inspection agencies, they suggest that to carry out the inspection without pre-notification would be beneficial by pointing out the factor 'Supervision by Government'. They also derived the factor 'Management Commitment' by quoting the role of middle management are more important to maintain and implement safety in the construction sites. The final factor from their study is 'Safety Policy promotion' and for that they derived that most of the Project managers do aware about the benefits of it, but they have no motivation as they promote only prior to the inspection arrival. [1]

DNMA Abdullah, Gloria Chai Mei Wern carried out research to investigate the factors that affect the safety culture in construction sector. They conclude that, safety culture within an organisation affects the commitment of both employers and employees towards safety management strategies in the construction sites. They have prepared questionnaire to identify the factors that can affect the safety culture. From that, they have suggested six factors that affect the safety culture. Which are, (a) The Enforcement from Authorities, (b) Cost Allocation, (c) Co-Operation and Commitment from All Parties, (d) Workers Background, (e) Relationship between Management and Workers and (f) Appropriate Incentives. [2]

Zubaidah Ismail, Samad Doostdar, Zakaria Harun examined some of the factors influencing the implementation of safety management system (SMS). They studied various influential factors that governs the success of SMS. They used Likert Scale to analyse the responses. They have derived four factors, 'Personal factor' which includes awareness, good communication, personal attitude, safety culture, positive groups, and personal competency. 'Resource factor' which includes hardware and software. Safety equipment, personal protective equipment (PPE) and any special requirements of the industry have to be adequately developed and provided. 'Management Factor' which includes leadership, vision, and direction, statement of objectives, commitment, supervision, safety analysis, and prevention planning. 'Relationship Factor' which includes globalization and interfaces with the stakeholders as well as internal personal relationships. They have also derived sub-factors from their analysis of above mentioned factors. The sub-factors are (a) Safety Awareness, (b) Safety Communication, (c) Safety Attitude and (d) Safety Competency. [3]

Abdelnaser Omran, Hazem Zaid studied the various factors affecting safety performance practice particularly in the construction contractor's work. The study was based on conducting questionnaire survey and targeted project managers, site engineers, and office engineers working for construction firms and consulting offices located in Gaza Strip (Palestine). 60 questionnaires were distributed randomly to the targeted respondents, 47 (78%) questionnaires were returned and analysed. They concluded following factors in their study which are (a) Pressurize Workers to Complete the Job Quickly, (b) Poor Attitude, (c) Extensive Use of Sub-Contractor, (d) No Safety Plan and (e) Contractor Don't Enforce the Safety while Performing Tasks. [4]

Thanet Aksorn, B.H.W. Hadikusumo identified 16 critical success factors (CSFs) of safety programs from safety literature and previous research. The study was conducted through questionnaire surveys with 80 respondents from medium and large-scale construction projects taking part in that. They choose 16 factors from their literature study for the further analysis for their research. They used SPSS to analyse the factors in the order of the degree of influence. The followings are the 16 factors,

Management Support, (b) Appropriate Safety Education and Training, (c) Teamwork, (d) Clear and Realistic Goals, Effective Enforcement Scheme, (f) Personal Attitude, (g) Program Evaluation, (h) Personal Motivation, (i) Delegation Of Authority And Responsibility, (j) Appropriate Supervision, (k) Safety Equipment Acquisition and Maintenance, (l) Sufficient Resource Allocation, (m) Continuing Participation of Employees, (n) Good Communication and (o) Personal Competency. [5]

Jimmie Hinze, John Gambatese conducted a study to identify factors that significantly influence the safety performance of specialty contractors. The study was composed of separate surveys of three different specialty contractor populations. From their literature study, following factors are found to affect the site safety particularly in the speciality contractor's work. The most critical factors from them are, (a) Training with the Assistance of Contractor Associations, (b) Implementing Employee Drug Testing, (c) Minimizing Worker Turnover and (d) Growth in Company Size. [6]

Rafiq M. Choudhry discusses empirical research aimed at why construction workers engage in unsafe behaviour. They have carried out interviews which are conducted in Hong Kong with workers who had been accident victims. They have also recorded participants' information such as age, experience and work environment. In their study, seven individual accidents and resulting injuries as reported by the injured operatives are described. They have examined work-in-progress briefly to report which was an attempt to acquire and disseminate knowledge as to why operatives performed work in an unsafe behaviour at construction sites. Furthermore, in-depth semi structured interviews were also carried out by them, which provided a rich data base allowing a grounded theory approach to be adopted to identify emerging themes during their data analysis. The findings indicated that workers were involved in unsafe behaviour because of the following factors, (a) Lack of Safety Awareness, (b) To Exhibit of Being 'Tough Guys', (c) Work Pressure, (d) Co-Workers' Attitudes, (e)

Performance Pressure, (f) Job Security, (g) Education and (h) Safety Orientation And Training. [7]

D.P. Fang, F. Xie, X.Y. Huang, H.Li used an empirical research on workplace safety management performance on construction sites in China. They have identified eleven factors that correlate closely with onsite safety management performance which was also proved to be useful in other safety related studies. For their research work, they have carried out literature review to identify and categorize hazards in routine safety management on construction sites. After reviewing various studies, they have prepared a questionnaire survey, which was then conducted on 82 construction sites. The factor analysis method was utilized by them. From their factor analysis, they have extracted 11 factors. Furthermore, they have also make in-depth analysis of the identified factors in other statistical methods to make more findings. Identified factors are, (a) Safety Inspection, (b) Safety Meeting, (c) Safety Regulation Enforcement, (d) Safety Education, (e) Safety Communication, (f) Safety Cooperation, (g) Management-Worker Relationship and (h) Safety Resources. [8]

C.M. Tam, S.X. Zeng, Z.M. Deng examined the status of safety management in the Chinese construction industry, explore the risk-prone activities on construction sites, and identify factors affecting construction site safety. Their findings reveals that the behaviour of contractors on safety management are of grave concern, including the lack of provision of personal protection equipment, regular safety meetings, and safety training. The study also proposes that the government should play a more critical role in stricter legal enforcement and organizing safety training programs. From their analysis, the main factors affecting safety performance of the construction sites are, (a) Poor Safety Awareness of Top Management, (b) Lack of Training, (c) Poor Safety Awareness of Project Managers, (d) Reluctance to Input Resources to Safety and (e) Reckless Operations. [9]

Chia-Kuang Lee, Yusmin Jaafar identified and prioritized the degree of importance of the factors that influence the safety performance on construction sites as perceived by the contractors on sites. For their analysis, they have conducted a survey which was carried out by the form of a questionnaire. Their prepared questionnaire was administered to 110 major construction companies in Malaysia to implore the safety factors from Grade Seven (G-Main contractors. About 63 main contractors participated in their survey, which achieved a high response rate of 61%. Their study prioritized the factors by using relative importance indices (I). The result revealed that the most important major factors are, (a) Safety Inspection, (b) On Site and HQ-Management Attitude Towards Safety, (c) Safety Regulation Enforcement, (d) Safety Communication, (e) Well-Written and High Standard Policies, (f) Safety Standard of Procedure for Work Processes and (g) Adequate PPE that is Aligned with the Nature of Work. [10]

Victor Y. Haines III, Gregoire Merrheim, Mario Roy aimed to find out the reactions of the site safety when appropriate incentives are introduced in work. For their analysis work, they have used structural equation modelling & cross-level analysis procedures. Their study investigated the relationship between individuals and group level variables and they have try to understand the various

reactions of the personals when incentives are introduced in their work. Their findings indicates that, safety incentive programs are more likely to be effective components of the health and safety strategies only when they are implemented in settings with positive supervisor-subordinate relationships. They concede that, Incentives factor is one of the determinants that motivate workers to behave in a desired manner to safety regulations on site. It can be viewed a psychological approach that rewards workers for their adhered routine on site Safety Inspection. [11]

Evelyn Ai Lin Teo, Florence Yean Yng Ling studied for the need to improve the effectiveness of SMS and SMS audit, the aim of their study is to propose a method to develop and test the tools that auditors may use to assess the effectiveness of a construction firm's SMS. The research methodology adopted in their study consists of 15 steps. Surveys were conducted; safety experts were consulted and invited to express their views, either through interviews or workshops. The Analytic Hierarchy Process (AHP) and Factor Analysis were used to assist in identifying the most crucial factors and attributes affecting safety. In this study, they have conclude that, If safety management systems on sites are complimented with a comprehensible policies that is well versed by all personnel on sites, employees will be able to execute any safety system in parallel with their nature of work. [12]

Catherine Hetherington, Rhona Flin, Kathryn Mearns examined the safety and problems regarding safety in marine industry. Although their research work is on marine safety, by studying their research work, the importance of the inspection in preventing hazards are revealed. Which are more often related to the construction site safety also. From their detailed survey and analysis, it is found that, Safety on sites can be improved effectively provided that safety inspection can function as a continuous improvement tool to benchmark safety at workplace. Hence, from their work, it can be conclude that, inspection can be a key factor in performing and achieving construction site safety. [13]

Ryan Olson, Ariel Grosshuesch, Sara Schmidt, Mary Gray, Bradley Wipfli examined the use of personal protective equipment (PPE). They have carried out video analysis of the site work to find out the necessary data for their study requirement. They have evaluated the effects of the collective behaviour of multiple social models on the use of personal protective equipment (PPE). From their study following factors can be derived, (a) Effective and Organized Technicalities, (b) Proper PPE that is Suitable for the Various Nature of Work and (c) Hazard Identification. [14]

Evelyn Ai Lin Teo, Florence Yean Yng Ling, Adrian Fook Weng Chon proposed a Policy, Process, Personnel and Incentive (3P + I) framework which may help project managers manage construction site safety. They have carried out a postal survey of contractors in Singapore to conduct the test of the framework. They have recommended that project managers must pay more attention to the important factors identified in their study which can help them to enhance the performance at construction sites and reduce the frequency of accidents. From their study following factors are derived, (a) Inadequate Company Policies, (b) Unsafe Practices, (c) Poor

Attitudes of Construction Personnel, (d) Poor Management Commitment and (e) Insufficient

Safety Knowledge and Training of Workers. [15]

S. Thomas Ng, Kam Pong Cheng, R. Martin Skitmore made objective Safety Performance Evaluation (SPE) framework. In their study, the importance of SPE factors is examined through a questionnaire survey conducted in Hong Kong. The results of the questionnaire survey are used by them to develop a SPE framework which is suitable for use in the construction industry and protocols for evaluating the safety performance at the organisational and project levels. From their study, they have find out several factors which can affect the construction site safety and hinder the path of the SPE framework. The critical factors are, (a) Project Management Commitment, (b) Hazard Management, (c) Safety Training and (d) Review of Safety Requirement in Subcontractor's Selection. [16]

K.Mohammed Imthathullah Khan, K. Suguna, P. N. Raghunath presented a study in construction industry to improve the safety performance. The main objective of their study is to identify the critical success factors which are responsible for the implementation of safety management in construction projects. Their study was carried out by conducting questionnaire survey among the contractors and clients of various construction projects, for testing their experience in safety management system. They have analysed their questionnaire survey by using SPSS software. They have identify the critical success factors which are responsible for the implementation of safety management in construction projects. Following are the concluding factors from their study. (a) Safety Awareness, (b) Safety Training, Regular safety audit, (d) Lack of knowledge of the workers, (e) Lack of knowledge of the work. [17]

Mohammed Kamel Alaqqad identified the factors affecting the construction safety and to establish a tool to assess and improve the construction safety of construction companies. In his detailed study, eighty sub factors were identified and grouped into nineteen main factors. He has used Safety Performance Attitude Score (SPAS) and Accidents Frequency Rate (AFR) to measure the safety performance and developed a tool for assessing and improving the construction safety. According to them main factors are, (a) Personal Protective Equipment, (b) Administrative & Management Commitment, (c) Safety Educating & Training, Safety Inspections, (d) Disposal of Hazardous Materials & Waste, (e) Proper and strict condition for PPE. [18]

Xianguo Wu, Qian Liu, Limao Zhang, Mirosław J. Skibniewski presented a systematic Structural Equation Modelling (SEM) based approach for Prospective Safety Performance Evaluation (PSPE) on construction sites, with causal relationships and interactions between enablers and the goals of PSPE taken into account. According to a sample of their 450 valid questionnaire surveys from 30 Chinese construction enterprises, a SEM model with 26 items included for PSPE in the context of Chinese construction industry is also established and then verified through the goodness-of-fit test. They have selected, three typical types of construction enterprises, namely the state-owned enterprise, private enterprise and Sino-foreign joint venture, to measure the level of safety performance given the enterprise scale, ownership and business strategy are

different. From their questionnaire analysis following factors can be identified, (a) Safety climate & Culture, (b) Safety attitude, (c) Safety training, (d) Safety management system, (e) Work pressure and intensity, (f) Co-workers' influences. [19]

B. Analysis of the Review of Literature Articles

Through the review done regarding various factors that affects the construction site safety, large number of sub-factors or construction site scenario has been derived from the in depth review of the above listed articles. The analysis suggests that from literature review of the above 19 articles total 101 number of sub-factors were found. To each 101 sub-factors the derived main factors are 28 in numbers. The table-1 suggests that how often a derived factor repeats in different articles reviewed in above literature analysis. For example, Safety policy has been considered as critical factor in 13 number of literature study out of 19 total number of literature reviewed in this study.

Number	Derived Safety Factors	Repetition of Factor (in number of times)
1	Safety Policy	13
2	Safety Attitude	11
3	Safety Training	10
4	Management Commitment	9
5	Safety Awareness	7
6	Co-operation and Commitment from All Parties	6
7	Proper PPE	5
8	Safety Inspection	5
9	Safety Communication	4
10	Eradication of Hazards	3
11	Workers Background	3
12	Safety Competency	3
13	Work Pressure	3
14	Safety Supervision	2
15	Relationship between Management and Workers	2
16	Incentives	2
17	Extensive Use of Sub-contractor	2
18	Safety Budget	1
19	The enforcement from authorities	1
20	Cost Allocation	1
21	Co-operation from Contractor	1
22	Implementing Employee Drug Testing	1
23	Minimizing Worker Turnover	1
24	Growth in Company Size	1
25	Performance Pressure	1

26	Job Security	1
27	Safety Meeting	1
28	Safety Culture	1

Table 1: Derived safety factors and their repetitions in number of times

IV. CONCLUSION

By reviewing various literature articles regarding construction site safety and related to the various factors that affect the performance of the construction site safety, analysis have been made to identify the most frequent safety factors which often appears in the reviewed literature articles. It is found that although various kind of construction site scenario prevailed in different number of studies, all the studies has concluded that those sub-factors or construction site scenario are lies within the total number of 28 safety factors.

To conclude more summarized results, top safety factors has been derived by selecting the safety factors which has been concluded in at least 3 numbers of different literature articles. Fig.1 suggests the list of top 13 safety factors along with frequencies of them in reviewed articles.

Fig. 1: Top Safety Factor VS. Frequency of Safety Factors in Reviewed Articles

Furthermore as it is seen that there are certain number of factors which has been derived repetitively in

different studies, it suggests that, these safety factors have greater impact on the performance of the construction site safety. So if effective management of these safety factors are done then construction site safety may improve as most of the studies has concluded these factors in their studies. Thereby reviewing various literature articles, the study concludes the top 13 most frequent safety factors which affects the construction site safety as shown in fig.1. Furthermore, these review of literatures will be helpful for the future studies regarding construction site safety. Researchers can use concluded safety factors for further analysis like if they want to make effective safety management system or improve the performance of the construction site safety.

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