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Health and Safety Framework Using Analytic Hierarchy Process For Construction Projects

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Abstract – *The construction industry is one of the riskiest industry in all over the world. It is recognized to be highly risk prone, very complex and competitive where uncertainties emerge from a different source. Under-construction sites are loaded with numerous risks that possibly lead to countless accidents and a large number of deaths. Implementation of occupational health and safety standards at any working site is necessary to minimize such dangers. Health and safety risk and lack of protection of the workers are the major problems in the construction industry. Like many countries, health and safety risks and lack of protection of the workers are considered to be an important problem also in India. Therefore, the goal of this research work is to devise preemptive strategy for health and safety by identifying the risk factors which may affect the safety of the construction workers in India. To achieve the objectives, critical literature review was performed to identify the health and safety risk factors. All the identified factors in this research are significantly occurring and have significant impact. The study has achieved a mile stone in development of health and safety framework in construction industry that will help the project managers to analyze the project risk more e_ciently at an early stage. Based upon these analysis, proper remedial measures would be possible for incorporation at planning and strategy level to improve and manage these barriers.*

1. INTRODUCTION

The construction industry is one of the riskiest industry in all over the world. It is recognized to be extremely risk prone and distinguished as very complex, competitive and special where uncertainties emerge from a different source [1]. According to Pinto et el. [2], occupational accidents and hazards had a serious impact on health and safety as well as economy due to high costs associated with work injuries. In the background of construction projects, accidents account for 7.9-15% of the costs of non-residential projects. Raheem and Hinze [3] stated that small building construction industries do not have a safety policy such that dangerous conditions occur at their worksites and workers are vulnerable to toxic conditions at construction sites. Construction-based OHS discernment of countries and causes for occupational accidents do not change substantially, considering the fact that certain global and habitual signs exist in workers. Pinto et el. [2] identified that the health and safety management is looking forward to taking into account all accidents and hazards that are likely to place project workers at risk. Therefore, advanced health and safety planning seems inevitable to address the safety concerns. Compliance with safety requires key health and safety measures which must be carried out by workers in order to ensure a minimum level of safety at the workplace.

According to Amin bakhsh et al. [1] modelling technique (AHP) is a methodology for forecasting health and safety measures in construction projects. This modelling technique (AHP) has gained more importance and attraction due to the accurate and quick prediction that customize the falsified method of forecasting modelling techniques. Due to these forecasting modelling techniques, the hazards and risks mis-assessment and time-consuming method with cheap predictive techniques and tools are eliminated for accurate prediction. Wu and Chau [7], stated that modelling techniques commonly used due to their high versatility and broad applicability and these modelling techniques can be minimized by 17%. Most of the India's construction industries follow responsive strategies and policies instead of pre-emptive strategies. According to Wang and than. [6] analysis of case study of construction projects with the assist of modelling technique (AHP) ensures that the health and safety policies are correctly measured.

To the best of author knowledge, study to investigate the assessment of safety management practices by using modelling technique Analytic Hierarchy Process

1.1 Problem Statement

Ahmad et al. [10]; Raheem et al. [9], reported that the construction industries in India do not comply with health and safety standards for their workers which contains many factors. The present position of construction industry in India is failing to achieve its true potential due to number of factors which make it one of the reasons are the lack of health and safety standards. Accidents occurred because of worker's incompetency, work at height, running tools and machinery without safety gears, poor site management and inability to use personal protective equipment (PPE). The construction industry hires 7.3% of the overall labor force of India [11], but its accidents and injuries rate is 17.3% which is higher than that of other industries [12]. The majority of

construction industry's injuries are caused by a fall from height accompanied by lifting activity and electrocution [13]. Insufficient supply of fall safety equipment, lack of training, unrealistic construction time, and lack of availability of suitable anchorages points at construction sites have been found as causes of fall from height [14].

Unsafe acts and behaviour along with unsafe conditions lead to 98% of construction accidents. Occupational health and safety (OHS) rules and regulation are very unsatisfactory in India's construction industry. Even certain construction industries have no health and safety standards and policies regulations [15]. The financial standing of an organization remains one of the grey aspects in health and safety arrangements of construction sector. Keeping in view this aspect, it is very important to explore viable solutions that would help to adopted health and safety factors by the stake holders keeping in view their own financial constraints.

1.2 Research Objectives

The objectives of the study are to:

- Identify and analyze major risk factors for health and safety in construction industry of India.
- Assess these health and safety major concerns. factor.
- Develop a framework to determine the severity of risk factors for health and safety.pa
- Adopt multi criteria decision making technique to highlight major concerns and propose a hierarchical safety management model.

2. Research Methodology

The theory for this research is based on a detailed literature review which describes the health and safety problems in the construction industry of the India. This study has been outlined to highlight the health and safety risk factors impacting construction projects in order to meet the objectives of the OSHA guidelines related to health and safety at construction sites. A literature review was undertaken to study the relevant areas of current research work and to identify the risk factors of health and safety. Both survey and descriptive designs are used in this research. The survey methodology has been used to collect the information through questionnaire from site manager, construction professionals and construction workers at site. This study was conducted with descriptive research that assisted in evaluating the execution of health and safety rules and laws at construction sites. The Delphi method was used to short list the important health and safety factors and to develop a questionnaire. Statistical method has been used to examine the information obtained. After the data analysis, results and conclusions were derived.

3.4 Framework Development Using AHP

The analytic hierarchy process was first introduced by Saaty (1980). AHP is an approach for resolving the complex and ambiguous issues. AHP is an important tool for dealing with complicated decision making that can help in determining and weighing criteria, assessing the data gathered and advancing the decision-making approach, [1]:

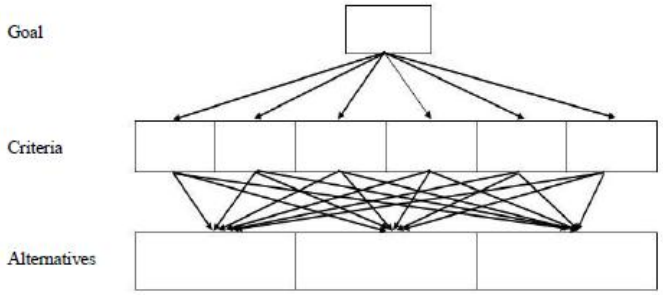

Fig -1 General structure of creating hierarchy,

The first step in the AHP is to construct the decision problem hierarchy. There is no specific rule that can be followed to construct a hierarchy. AHP enables the complex decision to be organized into a hierarchy and is structured to address the complicated problems at multiple hierarchy levels with a top priority as goal whereas medium levels are criteria and the lowest level as alternative [73].

3. Results and Discussions

139 questionnaires were distributed and out of 139 questionnaires, 107 questionnaires were received back. This represents the 77% response rate which is deemed to be very strong to make conclusions for a study. If the population size is unspecified any sample size greater than 96 can be considered as reasonable and appropriate [116]. According to Ashley and Boyd [117], 50% response rate is satisfactory,

60% good and above 70% rated really good. According to this statement, the 77% response rate was very good

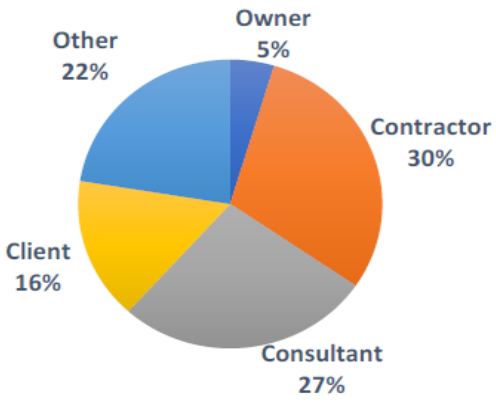

Fig 2. Types of organization

Figure 2 reveals that the respondents who filled the questionnaire, 5% were from owner, 30% from contractors, 27% from consultants, 16% from clients and 22% from other. The demographic statistics data indicates that majority of individuals are professional who filled the questionnaire.

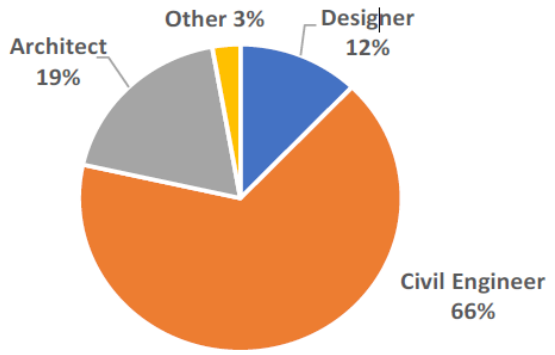

Fig. 3 Profession of the respondents

Fig 3. indicates that the major contribution was obtained from the civil engineers. The demographic response revealed that majority of individuals are professional civil engineers with a response rate of 66% and 12% were from designer, 19% from architect and 3% from others.

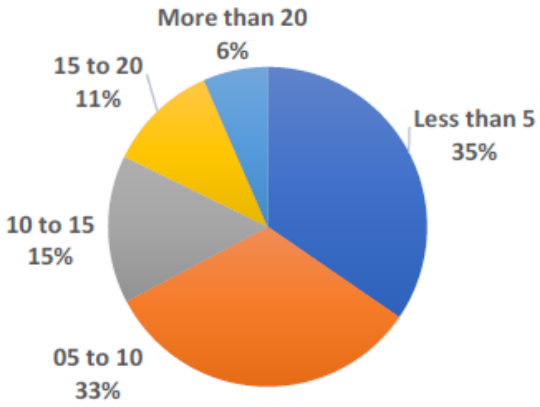

Fig 4.Working experience of respondents

The experience level plays an important role in enabling the professionals. Plenty of the respondents had experience of building construction projects. Figure manifests that 35% respondents have an experience less than 5 years, 33% have 05 t0 10 years, 15% have 10 to 15 years, 11% have 15 to 20 years and 6% have an experience more than 20 years. respondents have an experience less than 5 years, 33% have 05 t0 10 years, 15% have 10 to 15 years, 11% have 15 to 20 years and 6%

3.1 Reliability Analysis

The reliability test is one of the fundamental tests conducted to verify the reliability of the data. Reliability test is also known as Cronbach's alpha test. Cronbach's alpha test is a valuable analysis used to assess the reliability or internal consistency of any given data sets Statistics is used to assess the reliability test of inter item consistency. A higher value shows a strong relationship between the test items and a lower value shows a weaker relationship between test items. Reliability is acceptable if the alpha is within .70 and .99. If alpha value is greater than .70 it means the data is consistent for further analysis In our case study, Cronbach's alpha .931 is acquired which verify the consistency of data achieved. It means according to this statement; result of reliability analysis data is reliable and further analysis can be proceeded.

Table 1 Reliability value (Cronbach's alpha) of impact

Case Summary				Reliability Statistics	
		Number	%	Cronbach's alpha	No of items
Cases	Valid	107	100	.931	57
	Excluded	0	0		
	Total	107	100		

a. Listwise deletion based on all variables in the procedure.

3.2 Factor's Coding

Coding is a process of defining and detecting a connection between concepts. Coding is a means of indexing or categorizing the data in order to develop a framework of thematic ideas. This research comprises 5 health and safety risks factors. For the ease of risk evaluation coding C= (C1, C2, C3, C4, C5) are referred to each risk respectively and all the 5 health and safety risks factors contain 57 sub-factors and all of them is referred S= (S1, S2, S3, ... , S57) respectively.

3.3 Normality Test

The normality test generally called as Shapiro-Wilk test was used to observe the distribution pattern of the gathered data in SPSS statistical tool to determine whether the gathered data belongs to the normally distributed or not [97], Kim and Park. [100], have confirmed that non-parametric test is used where data does not observe as normal distributed. The test rejects the normality hypothesis if the p-value is smaller or equal to 0.05. It was observed that the significance value for magnitude of impact of 0.000 were obtained.

3.4 Kruskal Wallis Test

After normality test it was necessary to verify the level of perception of the respondents. Normality's hypothesis had manifested that data relates to non-parametric data. Hence, the Kruskal Wallis test was then conducted to evaluate the level of perception of the respondents. Kruskal and Wallis [102], reported that this test investigated whether respondents have same or different perception regarding each identified factor.

3.5 Framework Development Using AHP

Multi criteria decision approach is basically the analytic hierarchy process (AHP). The AHP approach for determining alternatives is relatively simple but technically effective multi criteria decision making approach. It helps decision makers to use a basic form of hierarchy in order to solve a complex issue and to analyze both quantitative data and qualitative data in a structured multi criteria decision making approach.

3.6 Relative importance Index

The five-point Likert scale was used in questionnaire survey to gather data. It consists of 5 parts as mentioned above and these 5 parts have been further classified into 57 sub-factors. Firstly, the relative importance index (RII) values of each subfactor were assessed one by one and then RII of all the 5 factors were determined respectively by taking average of all the subfactors of each part in order to assess the impact level and ranks.

3.7 Pair-wise Comparison Matrix

After attaining the (RII) values of all the factors and sub-factors, established the pair-wise comparison matrix by using the Saaty's scale for pair-wise comparison matrix and obtained the local weight of each factor and sub-factor. Factor with maximum weight has high impact at construction site than other factors.

The results and discussion have been detailed in this chapter. The response rate and demographic characteristic of the respondents were summarized. Three tests for statistical data reliability test, normality test and non-parametric Kruskal Wallis test was applied in this research work to obtain and assess the reliability level, nature and perception level of the respondents respectively. All the identified factors were referred with the code for the ease of understanding. In this chapter, health and safety problem in construction industry was structured as a hierarchy in the analytic hierarchy process to assess the weight of each factor to solve the major problem. Risk assessment was impossible only with quantitative approach because risk assessment is the combination of quantitative and qualitative evaluation. So, by using AHP-FCE method project risk grade level was evaluated. This helped to achieve the framework for a pre-empitive risk management strategy.

4. CONCLUSION

The main objective of this research work was limited to the development of health and safety framework keeping in view the concerns and problems in construction industry of India. Risk factors were further categorized to find out the potential impact of health and safety problems in construction industry of India. A detailed Delphi technique was applied to shortlist the identified factors. 107 filled questionnaires were received back, which was acceptable as supported by Osborn

1. The statistic of reliability analysis impact data was 0.931, means values greater than 0.7. This result justified that the impact data was reliable.

2. As per Kruskal-Wallis test, according to the respondent's, poor maintenance of equipment (0.028), inappropriate lifting of heavy weight (0.040), pandemic and viral situation (e.g. Covid-19, inuenza, dengue, fever) (0.045), frequent

3. Based upon the frequency data, RII values of all the 57 sub-factors in index layer and their 5 main factors in criteria layer were calculated one by one.

4. Relative importance index values of the 5 main factors accidents and hazards (0.709), unsafe acts (0.643), unsafe conditions (0.682), management system and social groups (0.625) and natural factors (0.598) were calculated.

5. Local weights of all 57 sub-factors and their 5 factors were calculated. Local weight of the 5 factors in criteria layer were accidents and hazards (0.150), unsafe acts (0.191), unsafe conditions (0.168), management system and social groups (0.226) and natural factors (0.274) were calculated. contact with people (0.008) have no significant impact.

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