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Assessment of Safety Practices of Construction Workers Using Analytical Hierarchy Process (AHP) : A Review

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Abstract-

Indian Construction Industry has shown immense growth in the past decades and is employing more than 5 crore workers at present making it the second-largest employer after agriculture. For the success of any construction project, the safety of both, the structures and the workers play an important role. Accidents and known injuries are more frequent on construction sites than in any other manufacturing sector. Thus, safety has to be a matter of utmost importance starting from the design stage to completion and handing over the construction sites. There exists a lack of proper coordination among the workforce, contractors, and clients in Indian construction industries which adds to the poor safe work conditions. Despite several safety practices and available labour safety laws, accidental incidents are increasing continuously. There becomes a requirement to gather the understanding the causes of these accidents and identify preventive measures to provide a safer work environment for the construction workers. This review talks about a systematic way for the assessment of safety practices of construction workers through the analytical hierarchy process (AHP).

Key Words: Construction Workers, Safety practices, Labour safety, Preventive measures, Risks, Accidents, Safety laws.

1. INTRODUCTION

With the employment of 9-12 % of every country's working population, the construction industry is one of the major industries in the world [2]. In India, it employs more than 5 crore workers, making it the second-largest employer after agriculture [3]. The severity of accidents leading to injuries and even worker's deaths makes the construction industry as one of the riskiest industries [4].

Though, the Indian construction industry caters both the latest technologies and large workforce involving both skilled and unskilled workers, safety, and health on the construction sites it still a serious matter of concern. It can't be estimated accurately, but the number of accidents taking place at construction sites is far more than our knowledge, because of a large number of undetected and unreported incidents. All these add up to the fact that comparatively, the construction industry is the most dangerous one with five times higher chances of fatality than any other manufacturing industry.

With the world's highest accident rates i.e. 165 out of every 1000 workers are injured on the job, Indian construction sites account for 16.4% of fatal global occupational accidents [5,6]. The accidents are accompanied by high-cost burdens and a large amount of time lost to the companies. All this led to the realization of the need for safety awareness among construction companies [7]. Construction site accidents and health problems are caused due to several factors. It was shown by the Occupational Safety and Health Administration examination that 39% of fatalities were caused by falls, 8.5% by electrocution, 8.4% by objects, and 1.4% by getting caught in between incidents [8]. In order to provide better safety and health conditions to the workers, several techniques can be followed which include – Safety organization and management, site planning and layout, working environment, personal protective equipment, first aid, safety policy, welfare facilities, and safety training to name a few.

Communication among the workforce, contractors and clients, and proper inspections play a crucial role in the management at construction sites. Lack of which leads to the fatality incidences at a construction site. Fall of the person from heights, ladders, and stairs, the collapse of building parts, falling of pieces of work on workers, scaffolding, excavations, hazardous processes, working on machines, tools and equipment are major factors for the construction site accidents. To avoid these fatalities, awareness must be created among the employees and the management as well [9]. Thus, every measure must be taken to create good practices and preventive measures for decreasing the number of accidents in the construction industry. Despite several proposed preventive measures, the accidents keep occurring at frequent intervals. This has led to the need for new effective prevention measures.

Good safety practices are being followed by companies carrying out large scale construction projects through a separate safety department, while local contractors or companies undertaking small scale projects lack proper safety measures in place. Every employer should keep safety and health of the employees as the topmost priority to reduce/prevent the chances of accidents occurring on sites. This article reviews the safety practices of construction workers through the Analytical Hierarchy Process (AHP) which is a multi-criteria decision aiding method.

1.1 Multi-criteria decision making -

Decision making is a crucial process in every company's functioning. The managers and other administrative authorities has to take decision at every crucial moments. Sometimes these decisions can be straightforward based on certain assumptions, inputs and prior knowledge while most often they tend to be more complex, requiring the problem to be broken down into smaller components. Considering both qualitative and quantitative factors, the complexity can be reduced by breaking it down and putting weightage to the components based on the prior knowledge and experience and later coming up with a decision after compiling those small components again [10]. This type of approach comes under a sub-discipline of operations research known as multi-criteria decision making and is used to find solutions to complex problems.

1.2 Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process developed by Saaty [11] is a multi-criteria decision-making method that considers experience, feelings, perception, and human judgment in the decision-making process. This review is focussed on assessing the safety practices of construction workers using the AHP approach. The AHP can be basically classified into three levels (Figure 1: **Hierarchy of criteria**)-

- 1) Identification of the issue and goal of decision making, putting them into a hierarchical manner based on related decision-making elements as indicators for decision choices.
- 2) Evaluation of alternatives based on the described criteria.
- 3) Final decision choices are made by selection of the appropriate alternative after the calculation.

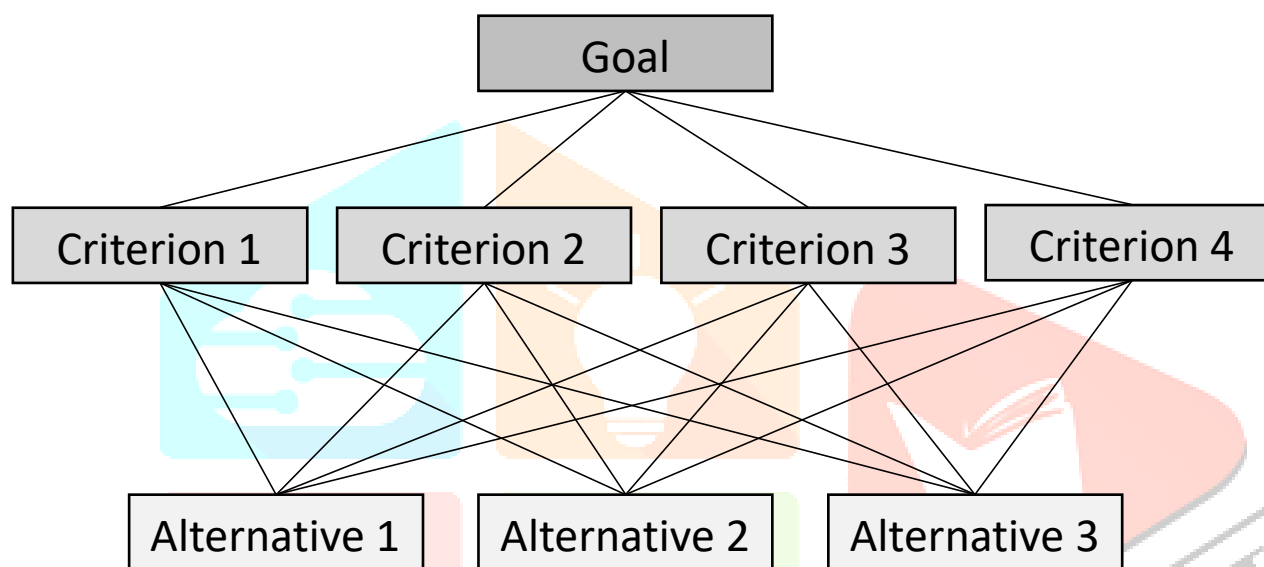


Figure 1: Hierarchy of Criteria

The comparison scale (Saaty Scale)

Comparison between any two elements can be made using AHP with the most widely used relative importance scale suggested by Saaty, 2005 [12]. The scale ranges from 1 to 9 and the relative importance of an alternative compared to the other can be determined (Table 1)

Table 1: Saaty Scale [12] for Relative Importance

Scale	Numerical Rating	Reciprocal
Extremely Preferred	9	1/9
Very strong to Extremely preferred	8	1/8
Very strongly preferred	7	1/7
Strongly to very strongly preferred	6	1/6
Strongly preferred	5	1/5
Moderately to strongly preferred	4	1/4
Moderately preferred	3	1/3
Equally to moderately preferred	2	1/2
Equally preferred	1	1

Based on the above relative importance scale, comparison matrices, the priority vector (eigenvector) and the inconsistency is determined. In this way every alternative is provided with a value that can be converted into a percentage, aiding to the decision making process. The safety practices of construction workers is a complex problem and need to be broken down into simple problems and based on that it could be compiled to formulate a solution. This has been done using AHP by several researchers while considering different values and weightage given to different criteria and alternatives.

2. REVIEW OF LITERATURE

The standards of occupational health and safety (OHS) have always been poor in the construction industry especially in developing countries, where they become worse. Prone to millions of accidents every year, construction sites affect the construction companies, employees, families, society, and economies. Despite being a booming industry, the Indian construction industry has never seen any significant improvement in the OHS standards. Neither the government nor the stakeholders have taken initiatives to implement OHS rules and regulations.

Huang and Hinze, 2003: This paper has taken a critical insight into the causes of accidents due to workers fall. The major finding after their analysis was that the height of fall was less than 9.15m in most cases which corresponds to the smaller construction projects, which could be because of the less importance given to the health and safety practices by the contractors [13].

Jannadi and Bu-Khamsin, 2002: A questionnaire survey and formal interviews were conducted with various stakeholders to identify the factors considered by the companies for the safety purpose resulting in the identification of 20 factors, and 85 subfactors [14].

Koehn and Datta, 2003: The detailed study resulted in the identification of the effects of safety rules and regulations on finances and productivity. It was found that there was an effect on both cost and productivity. While the costs can be reduced, productivity can be enhanced by avoiding the unnecessary breaks caused by accidents [15].

Pouresfandyani and Najiazarpour, 2019: In this paper, AHP was used to design and demonstrate a functional decision-making model for the managers of construction sites. It was suggested by the authors that this kind of AHP model can be used for risk management applications, by the managers and stakeholders involved in the large-scale construction projects. The authors also mentioned the necessity of using such models in today's time [16].

S Silva and Alves, 2009: In this paper, the application of AHP in occupational health and safety management practices was demonstrated. It was suggested that various companies can be evaluated based on their safety performance aspects using AHP model [17].

Janackovic and Savic, 2013: In this paper, a case study of road construction companies was used to demonstrate the application of the Fuzzy AHP model in the selection and ranking of occupational safety indicators. The model resulted in the identification of organizational factors as crucial players in improved occupational health and quality management systems [18].

Chan, Kwok, and Duffy, 2004: This paper also showed the application of AHP, where several alternatives were considered for the determination of priority in the OHS management systems. Resulting in detailed recommendations to the companies to implement their safety and resource allocation strategies [19].

Podgorski and Daniel, 2015: Selection of Key Performance Indicators (KPI) in the OSH Management systems is crucial for better safety practices at construction sites. In this paper, AHP was used to select the KPIs for OSH Management systems [20].

Ali and Shariff, 2016: Safety culture becomes the backbone of any construction company for OSH management. In this paper, the AHP model was used to identify and select crucial elements for developing a proper safety culture in companies [21].

Researchers have extensively used AHP as a tool to address the decision making challenges in the OSH management systems. Several key findings have been identified for the construction worker's safety using AHP which can be used in the future by construction companies to reduce the financial burden and costs associated with accidents by preventing those accidents through a proper systematic approach.

CONCLUSION:

With the involvement of machines and other complex systems, the construction industry is becoming more dangerous. The construction companies have to focus on earning profits while minimizing the fatalities which requires the proper establishment of safety management systems in place and regular monitoring of the same. Several organizations are also promoting the ZERO injury environment to make the construction industry provide better occupational conditions with minimal risks. The problem is complex and has to be dealt with a multi decision-making approach considering all the parameters. Through this review, we are able to conclude that the role of AHP in analysing and assessing the safety practices for the construction workers is very crucial and can help the organizations/companies reduce a lot of burdens caused by the accidents at construction sites. Utilizing several models used in the literature construction companies can identify the major risks associated and allocate resources judiciously while keeping the finances in control.

AHP can provide significant insights to the managers, companies, and other stakeholders about the different key performance indices, safety management practices, training, and resource allocation contributing a lot to the society, environment, and economy.

FUTURE SCOPE OF WORK:

The future scope of this work is to identify the causes and providing the best solutions to avoid/minimize the chances of accidents, safety problems, and injuries on construction.

Based on the models and methods identified in the literature review organizations and individuals can develop proper safety conditions on the construction sites.

Realistic and practical safety roles and goals can be established to reduce the uncertainty associated with safety management practices.

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