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Evaluation of Impact of Safety Training Programme in Indian Construction Industry – Analytic Hierarchy Process Approach

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Abstract: *Safety in the construction industry has always been a critical issue and large numbers of workers in industry are susceptible to the various workplace accidents and occupational health problems. Construction safety management indeed is a challenging task due to the dynamic nature of construction activity coupled with involvement of unskilled, illiterate and mobile work force. Construction hazards are more risky than other industries and the employees must have knowledge about hazards/safe operating procedures to mitigate the risk involved. Safety training is assumed to be an ongoing process to educate employees in safety matters, owing to the fact that it would enhance positive changes in safety procedure and legislation within organizations. Safety training helps employees to acquire the skills, knowledge and attitudes to make them competent in the safety and health aspects of their work. Nevertheless, to date far too few attempts have been made to empirically study the impacts and influence of safety training on safety performance, especially in developing country like India. The study attempts to identify safety training's impact with regard to improved safety outcomes over a period of time in an Indian construction industry and adopts Analytic Hierarchy Process (AHP) as a multi-criteria decision making technique for evaluating training programs. The factors characterizing impact of training programs are first identified using interviews with experts along with questionnaires. Once the factors were identified, the hierarchy was constructed and the factors were ranked according to their importance with respect to achieving the overall goal set for training.*

Keywords**:** *Analytic Hierarchy Process (AHP), Factor analysis, Impacts, safety training*

I. Introduction

Workplace conditions in construction industry are more hazardous compared to other industries, although the construction industry has become the most important sector contributing to economic development of the country. Workplace safety is a crucial component to organization competitiveness and in a more global context it has been noted that the most competitive countries are the safest countries[1].Implementation of safety practices in construction industry programme is always isolated and not integrated with other organizational functions in India. The safety management system has been widely recognized as the most effective way to improve working conditions, influences positive employees' safety attitudes [2].Now days, managements of construction organizations are emphasizing safety training as an important safety intervention within organization and training will help individuals in attaining knowledge, changing attitudes, and performing safe work behaviours . Safety training is a tool to change people's safety behaviour and attitudes in the workplace [3]. Attempts to examine safety training outcomes on the significant improvements in safety knowledge, safety attitude and safety behaviour, as well as safely performed work activities, have been identified in the literature ([4],[5],[6],[7],[8]). It is believed that it could help to reduce accidents, injuries, compensation costs and increase employees' safety awareness in the workplace ([9],[10]). By means of safety training, employees are expected to possess adequate knowledge and skill to promote safety in an effective way ([11],[12],[13]) as the ultimate goal of workplace safety training is injury prevention and control .Very limited research related to safety training and safety outcomes have been conducted in developing country like India.

Safety training is one of the most important techniques for developing human resources and it is concerned with improving employees' skills and enhancing their capacity to cope with ever-changing workplace hazards in construction industry. All employees in a workplace irrespective of cadre are to be trained on general aspects and on specific job contexts. Safety training outcomes helps employees to gain new knowledge and skills to perform their job effectively, but is also prepared to meet foreseeable changes that take place in their jobs. The efforts of safety trainings are to be transferred to the job context to achieve desire results and effective when it has translated to and enhanced job performance, as this gives more benefits to the organization ([14],[15],[16],[17]). Transferring the results of safety training is crucial in evaluating the effectiveness of training.

Results and effectiveness of training outcomes are evaluated by training models and number of training valuation models that exist in training literature. The purpose safety training evaluation is to ascertain learning outcomes by trainees and also whether achieving predetermined objectives results in better performance on the

job. Kirkpatrick (1998) noted that no final results could be expected from the training program unless a positive change in behaviour occurs. Therefore, it is important to observe if the knowledge, skills and/or attitudes learned in the programme transfer to the job. This framework is used for determining the success of the training programme using the four key items are reaction, knowledge, behaviour and results[18].Safety training is believed, to make a significant difference to both employee and organizational performance However, transfer of training and training evaluation to facilitate organizational effectiveness. Safety training has been used as an effort to change people's safety behaviour / attitudes in a workplace and also argues that safety training plays a role as a lower-order measure for controlling risk and it also should not be a substitute for proper risk control [3].Safety training is a planned activity related to safety and health with specific goals and application that is undertaken by an employee primarily so that they can apply new skills and knowledge.

II Material and methods

The study was conducted in Indian construction industry to evaluate the outcome of safety trainings employing analytic hierarchy process. The study was conducted in two stages; in first stage, identifying the factors characterizing impact of training programs through interviews with experts and framing a questionnaire. Factors were identified by conducting factor analysis and the hierarchy was constructed

1 Questionnaire Survey

From extensive literature review and subsequent discussions with corporate safety heads, safety managers of the construction organizations, a questionnaire was prepared comprising of 25elements. The questions were framed to fulfill the requirements of impact of elements of safety trainings in construction industry in India and shown in Table 1

Table 1 Questionnaire

S.No	Parameter	SDA	DA	N	A	SA
1	My role towards OHS is clear					
2	I have understanding about site safety rules					
3	I got opportunity to learn about safety issues associated with job.					
4	I apply knowledge gained through safety training in my job.[19]					
5	I share knowledge gained with co employees					
6	I gained knowledge through mode of training					
7	I feel safety trainings must be continuous					
8	I am in a position to give suggestions after safety trainings.					
9	I trust safety is everyone's responsibility					
10	I motivated through safety trainings towards safety					
11	Safety trainings have influence on my behavior.[20]					
12	I feel everyone must exchange safety issues with others					
13	I correlate learning's of safety trainings at workplace					
14	I practice and implement good housekeeping procedures.					
15	I apply &follow safe operating procedures [21]					
16	I follow work permit system wherever required. [21]					
17	I follow safe material handling procedures.					
18	I correct unsafe conditions at work place.					
19	I follow safety issues relating to occupational hazards/diseases.					
20	I report unsafe acts/conditions/near misses for rectification [21]					
21	I take shortcuts that involve little or no risk					
22	My work behavior was influenced after safety trainings.					
23	I always follow safety rules irrespective of risk involved.					
24	I give importance to safety than work if risk is associated					
25	I will not carry out work activities that are forbidden					

2 Data Collection

The suitability of the instrument to meet the purpose of the research is tested by conducting pilot study. The pilot study is useful tool to avoid mistakes in the real research and no one can write a perfect instrument, even though researcher has years of experience in developing instruments [22].

The developed questionnaire was circulated to safety professionals to ascertain reliability and internal consistency.

To conduct factor analysis, the questionnaire after examining the internal consistency was circulated to employees of all levels who have undergone safety trainings during the period Jan 2012 to Dec2012 are requested to exercise their options on 1-5 likert scale (1- strongly disagree and 5- strongly agree). A total of 500 questionnaires were sent equally to the respondents working in construction industry through e-mail and covering both infrastructure/ real estate segments. The process of sending and collecting responses from respondents took four months (Jan2013 to April 2013).The responses were verified for completeness and 426(85%) are found suitable for further analysis.

3 Analytic Hierarchy Process (AHP)

In order to evaluate the impact of elements of safety trainings in construction industry in India, AHP methodology was employed. The Analytic Hierarchy Process (AHP) is a theory of measurement through pair wise comparisons and relies on the judgments' of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgments that represents how much more; one element dominates another with respect to a given attribute. The judgments may be inconsistent, and how to measure inconsistency and improve the judgments', when possible to obtain better consistency is a concern of the AHP [23].AHP involves the decomposition of a complex problem into a multi-level hierarchical structure of characteristics and criteria with the last hierarchical level constituting the decision alternatives [24].

AHP is a systematic procedure that organizes the basic rational of the decision problem by breaking it down into smaller parts, then calling for a simple comparison with respect to pairs of judgments to develop priorities within each level of hierarchy. Finally, results are synthesized to obtain overall weights of the alternatives.

3.1Steps involved in AHP

The following paragraphs briefly describe the steps involved in AHP[25],

Step 1: Breaking down the decision problem into a hierarchy of interrelated decision elements .This hierarchy consists of at least three levels, the goal of the decision problem is placed at the top, the second level includes the criteria affecting the decision, and the last level contains the alternatives, which are to be evaluated and compared. Additional sub- criteria levels may be added where needed.

Step 2: Comparing the elements in each level in pairs using Saaty's scale, which is shown in Table 2. These comparisons are made using judgments based on knowledge and experience in accordance with their contribution to the main element in the level immediately above.Due to reciprocity, the number of needed comparisons for (n) criteria is given by n*(n-1)/2.

Table 2 Intensities of Relative Importance for Pair wise Comparison

Intensity	Definition
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Extreme importance
2,4,6,8	Intensities values between the two adjacent judgments

Step 3: Calculating the average relative weight vector.

Step 4: Calculating the relative weights of the alternatives with respect to each criterion. For (n) criteria and (m) alternatives, the relative weights of the alternatives with respect to all criteria will form an m x n matrix.

Step 5: Evaluating the consistency of the resulting weights Consistency is evaluated using the principal eigen values (λ_{max}) which is calculated through multiplying the pair-wise comparison matrix by the corresponding weights vector, then dividing the resultant matrix by the weights vector. Finally, the average value of the resultant vector λ_{max} is calculated. Once the value of λ_{max} is obtained, it is compared with the pair-wise comparison matrix size (n). If $\lambda_{max} = n$, a perfect consistency is said to exist, otherwise, there is an inconsistency with respect to the pair comparisons. Inconsistency is calculated using the consistency ratio (CR),

$$CR = CI/RI \quad (1)$$

Where RI is a random number index, the values of which are shown in Table 3.CI is a random index of a randomly generated reciprocal matrix and it is calculated as,

$$CI = (\lambda_{max} - 1) / (n - 1) \quad (2)$$

While, CI is a random index of a randomly generated reciprocal matrix and it is calculated as,

Table 3: Reference values of RI

N	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If CR < 0.1, then with respect to the pair comparisons are said to be consistent, otherwise, reasons contributing to lack of inconsistency are investigated, and logic is used to revise the comparisons until CR is acceptable.

Step 6: Calculating the overall weights of alternatives. The overall weights are determined by multiplying the relative weights of an alternative with respect to criteria by the relative weights of the corresponding criteria and summed over all criteria.

III Results

Firstly,the factor analysis has been carried out to develop a construct for options of impact of elements of safety trainings in construction industry in India.

1Pilot study

Preliminary study was conducted to ascertain the reliability and internal consistency of the questionnaire. A total of 100 safety professionals working in construction industry are requested offer their remarks on 1-5 scale (1-strongly disagree and 5- strongly agree) to measure internal consistency of the questionnaire.

The respondents are safety professionals response rate returned questionnaires is 90%.The data was inputted into MINITAB statistical software and conducted reliability analysis that is Cronbach's Coefficient α and the value for all options of the questionnaire is more than 0.75. If the Coefficient α value exceeds .7, it shows that the questionnaire has high reliability [26].The questionnaire was utilized without any changes to conduct factor analysis.

2 Factor analysis

The correct responses 426 were utilized to conduct factor analysis by principal component method &varimax rotation,using MINITAB.Twelve options failed to load more than 0.65 and were not considered and remaining 14 options which are loaded more than 0.65 are considered for furthur analysis. The options failed are 1,4,6,7,11,13,15,17,18,20 and 21 . The fourteen options are grouped in four criteria as safety knowledge,safe behaviour, safety attitude & safe practices and the details are shown in Table 4.

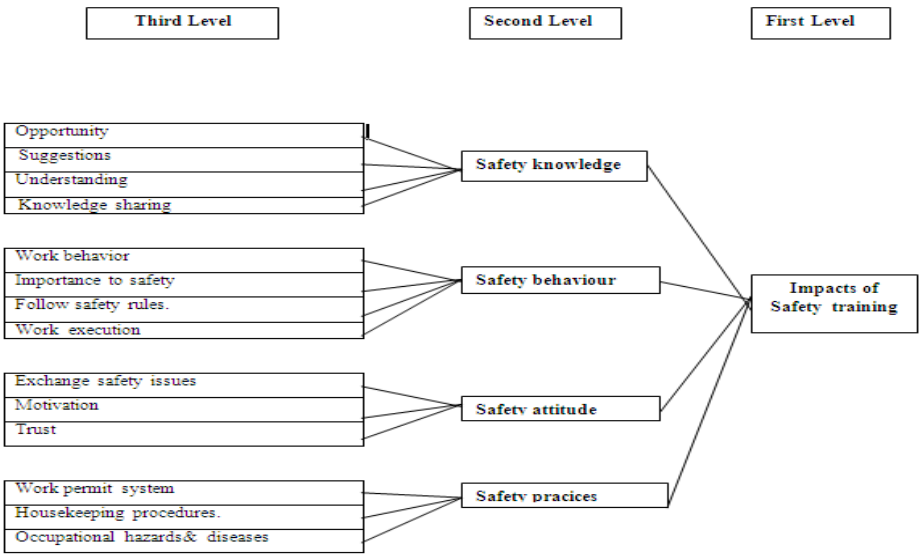
Table 4 Results of Factor Analysis

Criteria	Item No	F1	F2	F3	F4	α
safety knowledge	3	0.950				0.824
	8	0.932				
	2	0.929				
	5	0.923				
safe behaviour	22		0.981			0.786
	24		0.966			
	23		0.964			
	25		0.956			
safety attitude	12			0.969		0.886
	10			0.961		
	9			0.893		
safe practices	16				0.969	0.904
	14				0.957	
	19				0.858	

3 Hierarchical structure of impacts of safety training

Decision making hierarchical structure of impacts of safety trainings in construction industry is shown in Fig1.The impact of safety trainings consists of three levels that is objectives, criteria and alternatives. First level (Objective) is to identify the impacts of safety trainings and ranking them is the objective of the research. Second level (Criteria) is based on factor analysis results that are safety knowledge,safe behaviour, safety attitude and safe practices.Third level is to examine the validity and reliability of the alternatives related to every criterion.

Figure 1 Impacts of safety trainings



A group of six evaluators were interviewed for evaluating impacts of safety trainings .The evaluators are safety trainers, safety consultants and academicians in the field of safety engineering and all the evaluators are having more that 15 years of experience in their respective field of occupational health and safety. The objectives of the study was explained to the evaluators and requested to perform the rating. A matrix was obtained as results of pair wise comparisons.Inconsistency ratios were calculated to verify the consistency of the comparison process. The computations and analysis of interview findings were made using Analytic Hierarchy Process (Expert Choice, 2002). Table 5 shows the weights of the second level criteria of impacts of safety trainings. It should be mentioned that the consistency rate of this model is 0.035.

Table 5: Weights of safety training evaluation criteria

Criteria	Weight(percentage)	Priority
Safety knowledge	0.146	3
Safe behaviour	0.489	1
Safety attitude	0.319	2
Safe practices	0.046	4

The weight of the third level sub criteria, which shows the prioritization of the elements of safety training impacts based on weight percentage, are presented in Table 6.

Table 6:Weights of elements of safety training impacts(third level)

S.No	Critical Factors	Abbreviation	Weight %	Rank
	Safety knowledge			
3	I got opportunity to learn about safety issues associated with job.	Opportunity	0.656	1
8	I am in a position to give suggestions after safety trainings.	Suggestions	0.170	8
2	I have understanding about site safety rules	Understanding	0.114	11
5	I share knowledge gained with co employees	Knowledge sharing	0.060	13
	Safe behaviour			
22	My work behavior was influenced after safety trainings	Work behaviour	0.137	10
24	I give importance to safety than work if risk is associated	Importance to safety	0.509	4
23	I always follow safety rules irrespective of risk involved	Follow safety rules	0.045	14
25	I will not carry out work activities that are forbidden	Work execution	0.309	6
	Safety attitude			
12	I feel everyone must exchange safety issues with others	Exchange safety issues	0.089	12
10	I motivated through safety trainings towards safety	Motivation	0.559	3
9	I trust safety is everyone's responsibility	Trust	0.352	5
	Safe practices			
16	I follow work permit system wherever required.	Work permit system	0.249	7
14	I practice and implement good housekeeping procedures	House keeping procedures	0.157	9
19	I follow safety issues relating to occupational hazards/diseases.	Occupational hazards&diseases	0.594	2

IV Conclusion

Criteria for successful training program are identified. They are safety knowledge, safe behavior, safety attitude and safe practices. The most important criteria as per the results of impacts of safety training are safe behavior and safety attitudes which represent 49% and 32% respectively. As per Heinrich theory of accident prevention, the accidents are mainly due to unsafe acts (88%) and unsafe conditions (10%).The results of the study shows that safe behavior and safety attitudes contribute to 81% due to outcome of safe trainings and these two criteria are the major factors for unsafe actions which results in accidents. Focusing safety training programmes on safety behavior and attitudes will have positive effect in reducing accidents.

Elements of each sub criteria was identified and ranked. Basing on the rankings, it is concluded that the employees have got opportunity to learn about safety issues associated with work, to follow issues relating occupational hazards& diseases which will have long term effect on the health of the employees and motivating employees towards safety is a tool to develop safety culture in the industry. Conducting similar studies at the organization level is useful to prioritize the criteria and sub criteria of outcome of safety training programmes and to initiate measures to overcome deficiencies.

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