

ANALYSIS OF SAFETY AND HEALTH MANAGEMENT IN CONSTRUCTION INDUSTRY

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ABSTRACT: Construction, which is basic to developmental activities provide vital infrastructure such as transport, communications, power, water, and accommodation. This project evaluates existing regulations and importance given to the safety management in the construction industry. It also discusses problems associated with enforcing safety regulations at construction sites. So in order to identify the safety issues and problems, a questionnaire survey was conducted in sites and employees of the construction companies. From the collected data, we identify several factors which define the safety issues prevailing in the site. A detailed secondary study was conducted to view about the various problems associated with enforcing safety regulations at construction sites. The results of a questionnaire survey were used for the analysis through SPSS and ranking of the factors are found. Pareto analysis was carried out and based on the analysis it is found that the factors and sub-factors influencing safety and health management are the allocation of specific budget for safety requirements, agreement with insurance companies and financial motivation to application of safety under the main factor on economic investment and the sub factor of taking safety into account when designing a project improves safety under the main factor on project planning and design is in disagreement with safety and health management.

Key Words: Safety management, questionnaire survey, SPSS and Pareto analysis

I. INTRODUCTION

Safety and health management has greater impact in construction sector. Construction is a very big network with which every country is improving their infrastructure. As India is a developing country in which infrastructure plays a vital role. Construction is second biggest occupational industry in India. At the same time the construction industry ranks high in the rates of severe and fatal occupational injuries due to complexity and unpredictable nature of the tasks as only less importance is given to the safety and health management of the workers. Throughout the world, the construction area of civil engineering is the most hazardous industry.

The major causes of accidents are related to the unique nature of the industry, human behaviour, difficult work site conditions and poor safety management, which results in unsafe work methods, equipment and procedures. Although regulations and plans are available, they are still under unavailable condition. Workers are not aware of their protection at their work place. Some important factors due to which the unsafe situation is continuing is human factor, legislation and financial issue.

Human factor- carelessness of the workers, management on safety and construction sector and unskilled labours (lack of knowledge and practice about the work they performing). Legislation the laws, rights and acts available for safety of an employee are unknown to their knowledge (proper education should be given to the employees about their job profile and their rights at the work place). Financial issue a major problem plays a significant role why the safety and health management is poor in the industries. Understanding of risk is an important in thing on the conceptualization of risk control strategies.

Most accidents on construction sites are preventable through implementation of an effective safety program. Unsafe conditions and accidents are usually a sign that something is wrong in the management system. Basics solutions are labour-management at site, health planning and management, education and training of workers and supervisors, new technologies, federal regulation, workers' compensation law, medical monitoring, and occupational health delivery. A significant relationship between the company's attitude towards safety and the employee dedication towards the same should be noticed identified. Hence this will be helpful for improving the safety and developing a new safety culture inside the organization which improves the mental, physical, and emotional well-being of employees. Safety performance is more relevant to the human factors.

The main objectives of this study are evolved through the literature survey and are listed below.

- To recognize and understand the importance of safety management in construction industry.
- Determine the factors which mainly affect the safety and health management in construction industry.
- To identify common accident at the site and analyse the reason behind accidents.

II. LITERATURE REVIEW

Gyi et al. (1998) did Case studies of occupational health management in the engineering construction industry. This paper considers seven case studies of the interviewees' perceptions of the existing situation with regard to health management. A clear perception of construction management role in safety and the prevention of injury is discussed. It is concluded by saying that Research in the area of health management of construction workers is urgently needed to provide guidance to the industry. The case studies confirmed that the limited health expertise among managers coupled with a lack of understanding of the potential role of health professionals in construction organizations, e.g., health surveillance, health and safety committees, specific health training, fitness for work and sickness absence management. The main difficulties envisaged in health management were the potential large costs involved; the sizeable, temporary and mobile work force; demonstrating cost-benefits to top manage.

Peckitt et al. (1998) made a comparative study of safety in culture the construction industry of Britain and the Caribbean. The concept of safety culture is concerned with managing health and safety risks. This paper examine health and safety risk management in the construction industry in two different parts of the world in order to gain a better understanding of factors that significantly impact upon the safety culture of this industry. Study includes Internal Psychological factors (attitudes, beliefs, perceptions safety climate: attitude scale interview) and External factors (behavior Risk management risk taking audit and observation, environment: climate economics history regulation equipment). Site safety management arrangements were explored during head office and site interviews at Caribbean and Britain. Both industries suffer from a lack of job security and training, effective quality management and trust. Accident and ill-health data for the construction industry are inherently unreliable due to the endemic failure to report non-fatal accidents, both in Britain and the Caribbean, and must therefore be treated with caution. The all accident incidence rates for the Caribbean construction industry were generally half the British. The result is Caribbean construction industry faces less technological risk than British as it uses less chemicals, complex construction techniques, plant and machine.

Edwin et al. (1999) studied about Factors affecting safety performance on construction sites. This paper discuss the top five important issues found to be associated with site safety were: (1) management talk on safety; (2) provision of safety booklets; (3) provision of safety equipment; (4) providing safety environment and (5) appointing a trained safety representative on site. This research commenced by reviewing the relevant literature on construction safety published by the Health and Safety Executive as well as Academic Journals. This was followed by exploratory interviews which took place with two operatives, two site managers and one safety. The interview discussions were focused on the causes of accidents and the attitude of workers toward safety on site. After the exploratory interviews, a pilot study questionnaire was designed and discussed with twenty personal (including the five in the exploratory interviews).

Adnan et al. (2001) factors Affecting Safety on Construction Projects. The results showed that 92.8% of respondents indicated that S&H process is negatively affected by competitive tendering. The construction managers mentioned that committed contractors who make an adequate allowance for safety and health may run the risk of losing the tender to a contractor who is less committed to safety and health. It has been observed that there is a close relationship between the age and experience of operatives and their level of safety awareness. The level of accidents tends to decline after the age of 30. The result suggests that the older the operative gets the more experienced he becomes, hence more aware of safety requirements. The results showed that management was more concerned with the problem of productivity .91.2% of the respondents believed that certain criteria such as good technical skill, training and experience should be considered as highly important to certify those who handle scaffolding. Construction managers stated that workers are reluctant to wear safety protective clothing. This is strongly related to operatives' personal attitudes towards safety protective clothing and equipment. This study indicated that management did not give enough importance to the training of operatives on how and where to use protective safety equipment and clothing.

Suchismita and Somik (2011) studied about Safety Improvement Approaches in Construction Industry. This article briefly explains nine major prevailing safety improvement approaches in the construction industry: (i) personnel selection, (ii) technological intervention, (iii) behavior modification, (iv) poster campaign, (v) quality circle, (vi) exercise and stress management, (vii) near-miss accident reporting,

(viii) safety climate, and (ix) zero injury technique. The results shows that safety improvement approaches discussed above have yielded positive results and reduced accidents upto 55%.And they insisted that Safety considerations should be incorporated in the design process from the very beginning to increase the efficiency. That In country to the prevailing safety approaches, which are implemented during the actual construction phase, design is more effective as it is introduced earlier in the design phase. Hence architects and engineers are in a position to make decisions about construction safety and reduce or eliminate certain identifiable risks before those risks reach the construction site at the designing stage itself.

Kanchana et al. (2015) studied on Labour Safety in Construction Sites. The authors insisted safety issues are to be considered right from the design stage till the completion and handing over of the structure. This paper examines and discusses in the detail total working hours, work shifts, nativity of the workers, number of accidents and type of injuries taking place in small and large construction sites. This paper reveals laws adopted for labour safety such as safety organization and management, safety policy, safety training, safety committees ,site layout, first aid, lighting, personal protective equipment and welfare facilities. Detailed questionnaire is designed in order to quantify the criteria influencing the safety at site with weight-age depending up on its importance. The cause for accident is unskilled labour, lack of training etc.,. Important conclusion were drawn out from the paper is the average age of the workers was found to be 32 years, maximum numbers of workers were native workers but migrant workers are ready to work for low wages. The average number of accidents was found to be 16.03in small construction sites. In both small and large construction sites, more number of accidents occurred due to body injuries accounting to 44.1% and 26.4%, respectively. In general, contractors and owners must give utmost importance to the safety of the workers.

Noppadon and Tanit (2016) factors influencing on safety management status and evaluation of safety management status in construction projects in Cambodia. The objectives of this paper are to present the factors influencing on safety management (SM) status and the evaluation of safety management status in construction projects in Cambodia. The status of safety management in construction sites were evaluated by observation and the interviews with evidences presented. The results of this research show that the probability of the factors influencing the safety management in construction sites of both local and international contractors were divided into two groups, including the high probability and low probability groups. The factors in high probability groups were accepted that they can influence on the safety management in construction site such as budget allocated for safety management, safety policy, awareness of project managers, safety training, safety organization, safety regulation, usage of personal protective equipment (PPE), site-accident investigation, and safety committee. The results were accepted based on the reliability of the data set from the respondents.

III. METHODOLOGY

The methodology adopted in this project is given in Fig. 3.1. The collection of data is by the method of survey. Several methods for collecting information from the industry were evaluated from various literatures. Public and private companies were selected for the questionnaire survey. Surveying with a help of questionnaire was found to be most efficient based on the literature review.

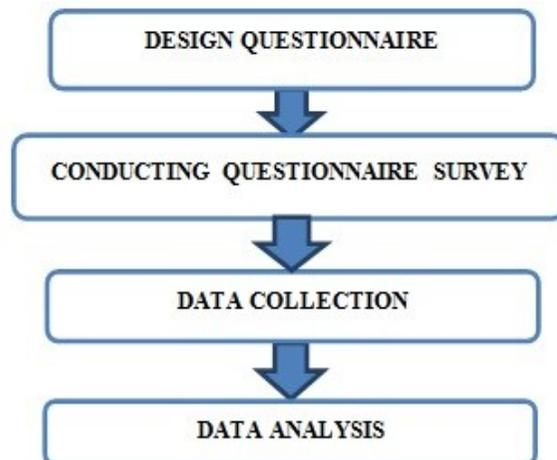


Fig-3.1 Methodology of the Study

IV. DATA COLLECTION AND DATA ANALYSIS

For successfully achieving the main objective of the study, one of the most important phases is collection of accurate data. Data collection is a procedure of collecting crucial data records for a certain sample or population of observations. Data is collected through the use of a questionnaire survey carried out with several factors and questions involved. The questionnaire will be circulated to several companies and will be received back for further analysis.

This chapter describes the results obtained from the 72 responses using Excel sheet. This chapter also includes respondent profile such as Number of responses, Year of experience, Number of project executed and Type of work involved. It also includes the average weight of factors affecting safety and health management in construction project.

The data interpretation is being provided in the form of bar charts for various factors and sub factors considered which is done based on the response provided in the questionnaire and the analysis is carried out by using spread sheet to determine the average weights of each of sub factors.

4.1 Questionnaire

The factors are extracting for questionnaire survey by literature study. It includes

- 1) Project planning and design
- 2) Contract documents
- 3) Safety organization
- 4) Implementation
- 5) Safety and health policy
- 6) Safety inspection
- 7) Personal protective equipment (PPE)
- 8) Safety and health promotion
- 9) Signs, signals and barricades
- 10) Role of government
- 11) Medical and fire prevent facilities
- 12) Economic investment

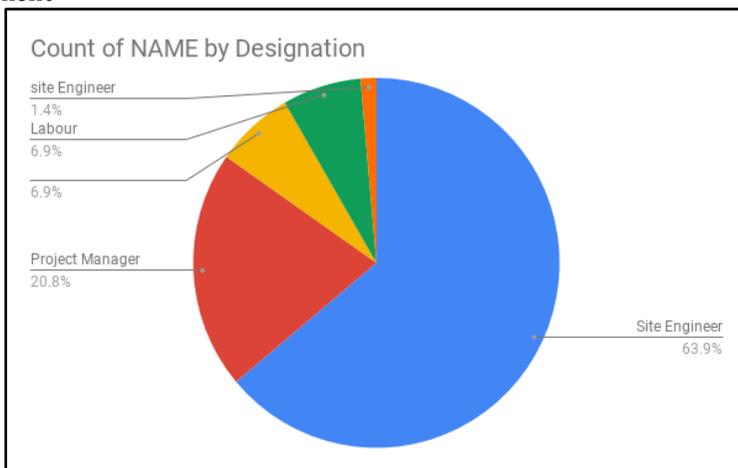


Fig-4.1 Position of respondent

4.2 General Information about the Responses

A total of 72 responses had been collected from reputed companies include both public and private sectors including various designations such as engineers and managers and contractors. The demographic details of the respondents are included below.

4.2.1 Position of respondents

On the basis of designation, about 67.9% of contribution has been made by Engineers, 20.8% of contributions have been made by project manager and the remaining 12.3% was by labours. Fig.4.1 shows the pictorial representation of Designation.

4.3 Analysis of factors

4.3.1 Personal protective equipment (PPE)

Of the 72 responses the ratings of the 2 questions under the sub factor of main factor personal protective equipment (PPE) is analysed and Fig.4.2 shows the data distribution of the various responses.

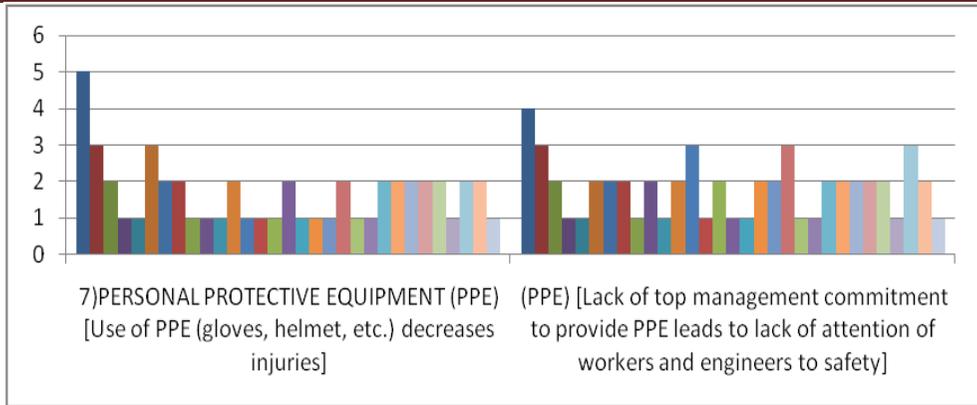


Fig-4.2 Personal Protective equipment (PPE)

1.3.2 Safety inspection

Of the 72 responses the ratings of the 3 questions under the sub factor of main factor safety inspection is analysed and Fig.4.3 shows the data distribution of the various responses.

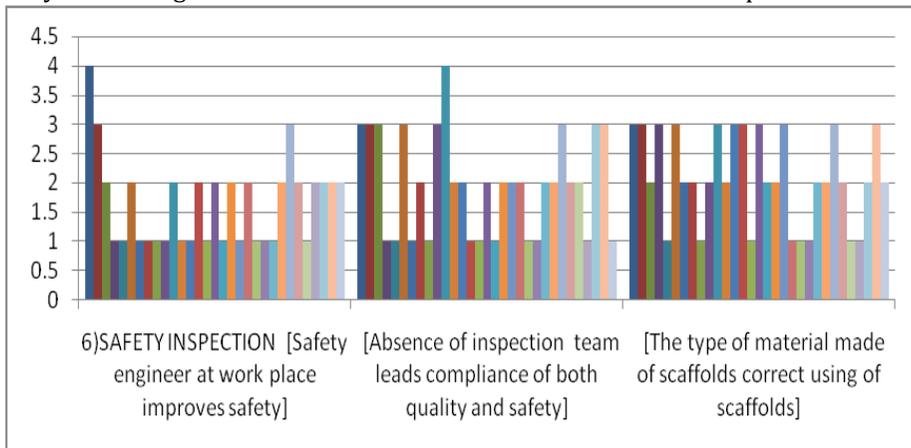


Fig-4.3 Safety inspection

V. OVER-ALL RANK OF ALL FACTORS CAUSING SAFETY AND HEALTH MANAGEMENT

Data is collected through the use of a questionnaire survey carried out with several factors and questions involved. In this study, factors contributing safety and health management have been obtained from various literature studies. The factors were grouped into different categories.

The data collected will be analysed by using the relative importance index (RII) method to rank the factors contributing safety and health management. RII is used to find the topmost factor leading to safety and health management.

Table 5.1 shows the Over-all rank factors causing safety and health management in construction industry. The factors economic investment and personal protective equipment are strongly agreed in safety and health management with RII value of 0.311 and 0.330 .while the factors safety and health policy and implementation are strongly disagreed with RII value of 0.409 and 0.400.

Table- 5.1Over-all rank of all factors causing safety and health management

FACTORS	RII	RANK
Economic investment	0.311	1
Personal protective equipment (PPE)	0.330	2
Signs, signals and barricades	0.334	3
Role of government	0.359	4
Contract documents	0.360	5
Safety inspection	0.362	6
Safety organization	0.370	7
Medical and fire prevent facilities	0.370	7

Project planning and design	0.380	8
Safety and health promotion	0.380	8
Implementation	0.400	9
Safety and health policy	0.409	10

The data has been analysed using SPSS version 13 software and the results have been tabulated in the above Table 5.1. From the above Table 5.1 it has been found that economic investment is found to be the most critical factor affecting the safety and health management having an RII value of 0.311, personal protective equipment and signs signals and barricades are the next critical factors having an RII of 0.334 and 0.330 respectively.

The least factors affecting the safety and health management of construction industry is safety inspection and health policy and implantation of safety in site having an RII of 0.409 and 0.4 respectively.

Table-5.2 T Test

Parameter	T	df	Mean difference	95% confidence interval of the difference	
				Lower	Upper
Economic investment	51.075	71	3.59052	1.2513	1.5298
Personal protective equipment	43.490	71	3.52011	1.3598	1.6804
Sign signals and barricades	50.775	71	3.76724	1.3803	1.9142
Role of government	45.792	71	3.66954	1.5108	2.1283
Contract documents	42.388	71	3.57414	1.7071	2.3412
Safety inspection	43.421	71	2.54344	1.8121	2.4310
Safety organization	47.345	71	2.56787	1.923	2.5634
Medical and fire prevent facilities	51.345	71	2.72342	2.011	2.7010
Project planning design	45.945	71	2.50987	2.109	2.8453
Safety and health promotion	46.876	71	2.98763	2.208	2.965
Implementation	48.786	71	2.56432	2.234	3.013
Safety and health policy	49.567	71	2.63454	2.298	3.123

From the above Table 5.4, the T test has been carried out using SPSS software and the critical factor is found to be economic investment. The confidence level of interval having the lower and upper bound is 1.2513 and 1.5298 respectively.

VI. PARETO ANALYSIS

Pareto analysis is a statistical method in decision making that is used for the selection of a limited number of tasks that create important overall effects. In general, the Pareto analysis technique is used to help project managers identify a specific number of tasks that cause significant number of problems. The key technique to identifying these root causes is the 80/20 rule, which suggests that the focus should be on those tasks that cause 80% of the problems

6.1 Steps in Pareto Analysis

The factor causing safety and health management is analysed using Pareto analysis. The following steps for this analysis is followed

Step 1: Calculation of the importance percentages of the main factors, by summing all the RII of each sub-factors, the equation is used to calculate the importance percentage for each main factors as shown in Table 6.1

$$\text{Importance percentages of the main factors } (\beta_i) = \frac{RII_i}{\sum_{i=1}^{10} RII_i} * 100\%$$

Table-6.1 Importance Percentage of Main Factors

S.No	Factors	RII _i	$\beta_i = \frac{RII_i}{\sum_{i=1}^{10} RII_i} * 100\%$
1	Economic investment	0.311	7.125
2	Personal protective equipment (PPE)	0.33	7.560
3	Signs, signals and barricades	0.334	7.652
4	Role of government	0.359	8.225
5	Contract documents	0.36	8.247
6	Safety inspection	0.362	8.293

7	Safety organization	0.37	8.477
8	Medical and fire prevent facilities	0.37	8.477
9	Project planning and design	0.38	8.706
10	Safety and health promotion	0.38	8.706
	Safety and health management	$\sum_{i=1}^{10} R_{Ii} = 4.365$	

Step 2: Calculation of the importance percentage of sub-factors, using the following equation.

$$\text{Importance percentages of the sub-factors } (\beta_{ijk}) = \beta_{ij} * \frac{R_{Iijk}}{\sum_{j=1}^k R_{Iijk}} * 100$$

Important percentage of all the sub factors are calculated and tabulated as shown in Table 6.2

Table-6.2 Importance Percentage for Sub-Factor

S. NO.	FACTORS	RII	$\frac{R_{Iijk}}{\sum_{j=1}^k R_{Iijk}}$	Bijk
1) PROJECT PLANNING AND DESIGN				
1	Taking safety into account when and designing a project improves safety	0.351	0.252	0.022
2	Emergency plans at company decrease accidents	0.332	0.238	0.021
3	First Aid at work place improves safety	0.352	0.252	0.022
4	Develop a risk management plan increase safety	0.36	0.258	0.022
2) CONTRACT DOCUMENTS				
1	Addition of safety into contract clauses improves safety and ensures compliance with safety	0.34	0.324	0.027
2	Inclusion of contractor safety and quality records into bid awarding process decreases	0.365	0.348	0.029
3	Regular and systematic analysis of accidents improves safety and decrease future accidents	0.345	0.329	0.027
3) SAFETY ORGANIZATION				
1	The organization should be formed with skilled personnel who exhibit characteristics necessary to achieve work safety objective.	0.365	0.495	0.042
2	The safety organization should be formed with culture and community considers safety a vital need for people	0.372	0.505	0.043
4) IMPLEMENTATION				
1	Implementation according to agreed specification in contract improves safety	0.38	0.136	0.013
2	Many change orders during implementation decreases productivity and increases accidents and injuries	0.41	0.147	0.013
3	Increases of material price leads to use of low quality material thus harms workers	0.412	0.148	0.014
4	Provision of plant and equipment maintenance	0.403	0.145	0.013
5	Provision of safety working environment	0.386	0.139	0.013
6	Conduction of safety system of works	0.391	0.140	0.013
7	Employment of safety officer and safety supervisor	0.402	0.144	0.013
5) SAFETY AND HEALTH POLICY				
1	The safety and health policy forms a part of a the company core values	0.391	0.195	0.018
2	Increase of material price leads to use of flow quality material thus harms workers	0.421	0.210	0.020
3	Quality assurance referring to international standards improves safety	0.386	0.193	0.018
4	Existence of written policy for quality standards improves quality	0.421	0.210	0.020
5	Top management commitment to safety improves quality	0.386	0.193	0.018
6) SAFETY INSPECTION				
1	Safety engineer at work place improves safety	0.36	0.327	0.027
2	Absence of inspection team leads compliance of both quality and safety	0.371	0.337	0.028
3	The type of material made of scaffolds correct using of scaffolds	0.371	0.337	0.028
7) PERSONAL PROTECTIVE EQUIPMENT (PPE)				
1	Use of PPE (gloves, helmet, etc.) decreases injuries	0.31	0.475	0.036
2	Lack of top management commitment to provide PPE leads to lack of	0.342	0.525	0.040

	attention of workers and engineers to safety			
8) SAFETY AND HEALTH PROMOTION				
1	All the employees know the result of accidents and injury investigation and follow up actions	0.382	0.209	0.018
2	The value of safety and health area adequately defined in your company	0.39	0.213	0.019
3	Health assurance program helps reducing injuries	0.362	0.198	0.017
4	Quick transfer of construction waste out of site reduce injuries	0.322	0.176	0.015
5	Design of scaffolds as international specification (OSHA for example)	0.372	0.204	0.018
9) SIGNS, SIGNALS AND BARRICADES				
1	The use of danger signs, caution signs , traffic signs improves safety	0.318	0.468	0.036
2	The use of barricades to close the site for pedestrians	0.361	0.532	0.041
10) ROLE OF GOVERNMENT				
1	Issuing laws, standards, regulations and legislation improves safety	0.356	0.330	0.027
2	Supervision implements laws, standard, regulation and legislation of safety	0.371	0.344	0.028
3	The punishment in case of violation of laws, standard, regulation and legislation of safety	0.353	0.327	0.027
11) MEDICAL AND FIRE PREVENT FACILITIES				
1	Periodical medical examination of workers Permanent presence of medical specialist in the site.	0.367	0.327	0.030
2	Availability of adequate fire extinguishers at site	0.362	0.323	0.030
3	Periodic maintenance of fire extinguishers which are located in the site	0.392	0.350	0.032
12) ECONOMIC INVESTMENT				
1	Allocating specific budget for safety requirements Agreement with insurance companies Financial motivation to application of safety	0.307	1	0.071

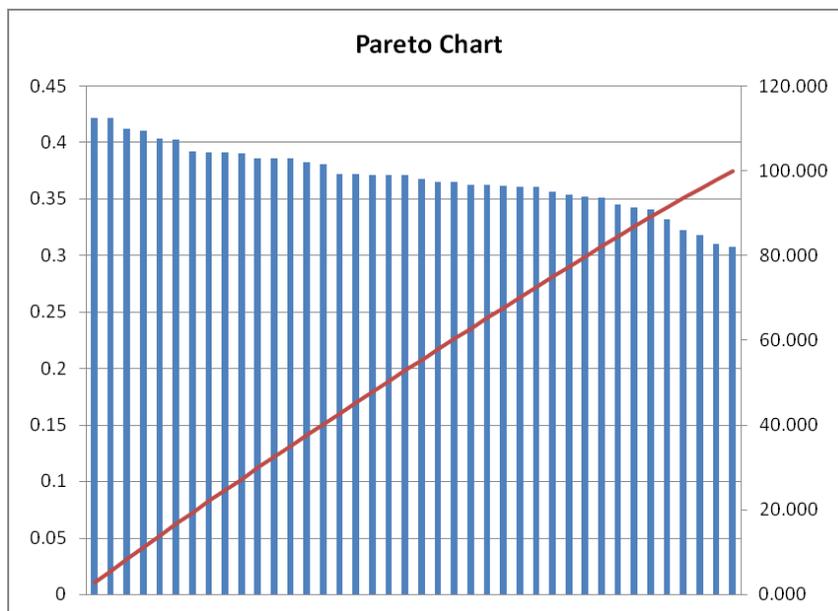


Fig-6.1 Pareto chart of all sub factors

Based on the calculated importance percentage of all the sub factors a pareto chart has been formulated in MS excel and the following inference has been made.

- The red curve in the chart represents the cumulative percentage of all the sub factors.
 - Out of all the sub factors nine have been found to be more prioritized
 - These nine factors are as follows
1. Allocating specific budget for safety requirements Agreement with insurance companies Financial motivation to application of safety
 2. Use of PPE (gloves, helmet, etc.) decreases injuries
 3. The use of danger signs, caution signs, traffic signs improves safety
 4. Quick transfer of construction waste out of site reduce injuries
 5. Emergency plans at company decrease accidents

6. Addition of safety into contract clauses improves safety and ensures compliance with safety
 7. Lack of top management commitment to provide PPE leads to lack of attention of workers and engineers to safety
 8. Regular and systematic analysis of accidents improves safety and decrease future accidents
 9. Taking safety into account when and designing a project improves safety
- By Pareto rule prioritizing these nine factors safety and health management in construction project can be improved.

VII. CONCLUSIONS

The study identified several health and safety management issues in Construction project. This study was under taken to recognize and understand the importance of safety management in construction industry.

The factors which mainly affect the safety and health management in construction industry were determined through a questionnaire survey. The data obtained from the survey was analysed in SPSS, Pareto and the key indicator which affects the quality of construction were identified and ranked.

As shown in Table 5.1 the economical investments in a project is found to be more critical. The sub factor- Allocating specific budget for safety requirements is given the most priority. Material quality, financial issues and labour management are the other key factors which affects the quality of construction projects.

Use of personal protective equipment and sign signals barricades decreases the number of accidents in construction site . Common accident at the site was identified and the reason behind accidents was analysed.

The least affecting factor is Top management commitment to safety in improving quality and safety inspection. Additional investment has to be made in order to increase the level of safety at site. Insurance, personal protective equipment's, barricades, signs has to be provided for the labour at site.

Various construction sites were survived and based on the responses obtained from the site engineers and workers recommendations to improve safety and health management were derived. The various recommendations to be followed based on analysis are discussed below.

- Awareness must be created among all employees about the functioning of Safety Committee and encourage them to report on any safety related issues
- Safety Committees headed by Project Managers should be formed and frequently meet to discuss matters related to safety
- Effective induction training programmes should be conducted for the new recruits.
- Work procedures should be reviewed periodically
- Well qualified experienced Safety Officers should be employed
- Warning signs should be erected at appropriate locations
- Awareness on the importance of PPE should be prioritized
- Site Supervisors should enforce that all the workers must be equipped with PPE and wear them while on duty.
- Managers must pay more attention to health and safety management issues within his command area.
- Managers must get involved in all matters relevant to safety.
- Officials from the Labour Department should visit the construction sites randomly to check the compliance.

Further research on Health and Safety Management in construction projects specifically in Economic investment, Personal protective equipment (PPE), Signs, signals and barricades are suggested to improve the health and safety of the workers engaged in construction work.

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