

Effective Safety Management in Construction

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Abstract - Construction is a significant economic activity in India. The construction industry employs people of all skill levels, from highly skilled to completely unskilled labourers. In the construction industry fatality is five times more than in the manufacturing industry, where the risk of a major injury is two times higher. The aim of Paper is to examine the evaluation of various parameters such as accident analysis, accident causes, and types of accidents in a construction working environment. Based on the study of various accidents and various literature 19 unsafe act, conditions and 22 reasons for the accidents and Injuries are identified which affect the projects in India. Also, Critical factors are identified and analysed from the questionnaires through relative importance index technique in order to deal with their possible solutions by mitigation technique so, that can be useful to construction industry to minimize the accidents, to reduce the cost of construction project and to avoid future project delays and failures.

Key Words: Safety Management, Simulation, Construction, Virtual Reality, Unsafe Act and Condition, Accidents.

1. INTRODUCTION

Construction is India's second largest economic activity, after the agriculture. Construction workers account for 7 to 8% of the global labour force, and this figure may be as high as 15% to 20% in some countries. Construction is a significant economic activity in India. The construction industry employs people of all skill levels, from highly skilled to completely unskilled labourers. On a construction site, several people work at different levels at the same time. Workers, machines, and overhead cranes should all be required to work in a congested area. The work should be completed as quickly as possible. As a result, construction work is inherently dangerous. A fatality is five times more likely in the construction industry than in the manufacturing industry, where the risk of a major injury is two times higher. According to a recent study by the International Labour Organization (ILO), India has the world's highest accident rate among construction workers, citing one survey by a local aid group that found that 165 out of every 1,000 workers are injured on the job. (S. Kanchana, 2015) As a result, it is necessary to promote the safety programme in order to gain the employees' trust and support. All available means, such as group meetings, posters, signs, and pictures, should be used. The employee must be provided with a safety programme from the time they are hired. Constant

education and training are required to create a safe working environment for employees. Every individual is to have a mental attitude that is as close to automatic in its reactions as humanly possible. This is possible through a process of continuous education training.

Safety can be defined as an individual's physical and mental readiness to perform a task safely. Safety, like discipline, is a way of life, a state of mind, and a habitual force. Because the construction industry is so complex, it is prevalent with health hazards. As a result, safety is a critical concern in the construction industry in order to achieve a risk-free environment. According to safety professionals, the majority of workplace accidents are caused by unsafe behaviour, and controlling it is one of the keys to successful accident prevention, resulting in a low accident rate on construction sites. The number of fatal construction accidents is difficult to quantify because data on this topic is unavailable in most countries. The primary concern is completing projects with the required quality in the shortest amount of time and at the lowest possible cost. Carelessness has been identified as the leading cause of construction site accidents and hazards. The construction industry is prone to accidents due to changes in timing and schedules, as well as changes in men themselves, as well as the nature of the construction jobs. Hence, the aim of this paper is to reduce accidents on construction sites.

1.1 Importance of Safety

Safety reduces project costs because any accident increases the project's indirect costs. It is the moral and legal obligation of the construction manager to provide a safe working environment and of the workers to work safely. The project runs on time because if an accident occurs, it affects the project's scheduling, work site, and the project may be delayed. therefore, safety also take care of time. The project's efficiency will improve. Also, negative image for the client and a negative effect on a contractor's reputation when the project has a high accident rate, so the company's reputation will be better.

1.2 PDCA Cycle

The safety management team of all construction company team should follow's "PDCA" cycles to ensure the site safety. PDCA stand for:

Plan: From the hazard and risk assessment, the safety policy and procedures are defined and the resources allocated for putting them into action.

Do: The policy and procedures are applied.

Check: Safety performance is measured, in order to check on the relevance, completeness, effectiveness, and efficiency of the implementation.

Act: Any appropriate remedial measures or improvements are defined, leading back into the planning, to restart the cycle. (team, n.d.)

The PDCA cycles cover both IS-14001 environmental management system and IS-18001 occupational health safety assessment series. For ensuring safety and health at construction site we have study the types of hazards and identification of unsafe act and unsafe condition and other reasons that may cause risk.

1.3 Need of Study

The goal of this project is to know and understand about the importance of safety in construction projects. Several accidents occur in construction projects, which may cause the project to be delayed and may also increase the project's cost. Construction is one of the most dangerous industries in the world. Many projects in India are being delayed or stopped due to inadequate safety measures and a lack of knowledge about proper on-site safety techniques. Various types of accidents occur during the execution construction project. As a result, there is a need to investigate and identify the root causes of accidents in order to reduce their occurrence. So, accidents must be managed properly in order to avoid future project delays and failures.

1.4 Objective

1. The Paper examines the evaluation of various parameters such as hazard analysis, accident analysis, accident causes, and types of hazards in order to obtain unsafe acts, unsafe conditions and other reasons in a construction working environment.
2. The primary objective of this research paper is to minimize the accidents in construction industry.
3. Also, the paper deal with simulation-based model by indicating fire safety equipment in order to prevent property losses and lives of people.

1.5 Scope of the Project

The scope of the project is to investigate safety and control measures in building construction projects in Gujarat, India through questionnaire surveys of various construction projects in Ahmedabad and Godhra, Gujarat, India. Also, Critical factors are identified and analysed from the questionnaires in order to deal with their possible solutions that can be useful to construction industry to minimize the accidents.

2. LITERATURE REVIEW

Literature review has been done by referring various research papers and by gathering all the information required from those research papers like the factors which affecting the safety management on construction projects, the connection between management practices and performance in the construction sites, to explore more about the effects of acute and chronic hazards, by using Revit and Navisworks, make a model that includes project data, risks source management, and Simulation based training to avoid accidents in construction industry.

3. RESEARCH METHODOLOGY

The research is done in two parts. The first part is done by the questionnaire survey and the second part is done by preparing simulation-based model.

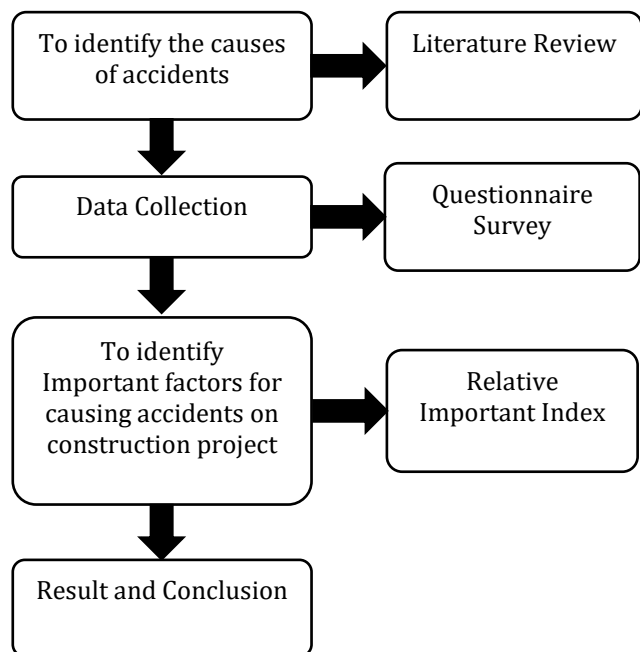


Fig 1 Methodology

4. DATA COLLECTION

4.1 Questionnaire Survey

Based on the study of various accidents and various literature 19 unsafe act and unsafe conditions are identified which effect the projects in India. Also, 22 reasons for the accidents and Injuries are identified which affect the projects in India. To get the genuine response from the employees of various construction companies in Ahmedabad and Godhra, Gujarat, India by distributing a self-prepared questionnaire to the companies and receiving their responses.

4.2 Simulation-based Model

Simulation based model is prepared on sketch up software to indicate the various safety equipment like Fire extinguisher, Emergency Exit, Fire alarm, Water sprinkler and Fire protective curtain.

5. DATA ANALYSIS

5.1 Questionnaire Survey

The questionnaire survey was distributed to the people who worked in construction industry and got 82 responds out of 100. The respondent's profile (Their Organisation/Company, their role/responsibility and experience) and Number of accidents happened in a week on respondent's site shown below:

5.1.1 Respondents Profile

What is a type of organisation/company do you work for?
81 responses

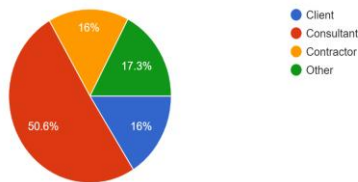


Fig 2 Types of organisation/company do respondents working

According to survey, 50.6% respondents are consultants, 17.3% respondents are working in other organisation/company and 16% respondents are clients and contractors.

What is your role/responsibility within your organisation/company?
81 responses

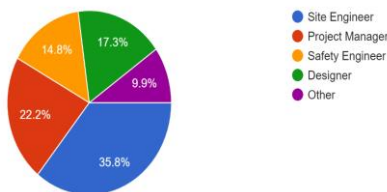


Fig 3 Role/responsibility of respondents

According to survey, 35.8% respondents are site engineers, 22.2% respondents are project managers, 17.3% respondents are Designers, 14.8% respondents are safety engineers and 9.9% respondents has other role/responsibility within organisation/company.

How many years of experience do you have?

81 responses

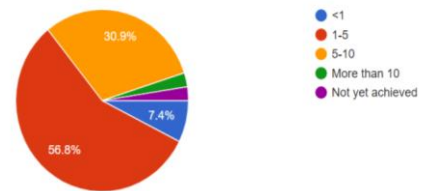


Fig 4 Experience of respondents

According to survey, 56.8% respondents has between 1-5 years of experience, 30.9% respondents has between 5-10 years of experience, 7.4% respondents has less than 1 year of experience and 3.7% respondents has more than 10 years of experience.

Number of accidents happened in a week on your site?

81 responses

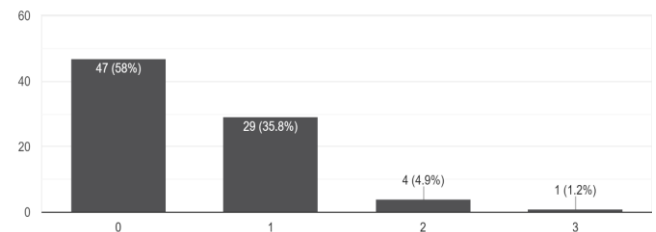


Fig 5 Number of accidents happened in a week on respondent's site

According to survey, 58% respondents said, there is no accident happened in a week on their site, 35.8% respondents said, there is one accident happened in a week on their site. 4.9% respondents said, there are two accidents happened in a week on their site and 1.2% respondents said, there are 3 accidents happened in a week on their site.

5.1.2 Relative Importance Index Technique

It is used to assess the relative importance of the various delays, causes and effects. The same method will be used in this study through all groups (i.e. contractors, project safety, owner and site supervisor). For each factor, a four-point scale ranging from 1 (very low affect) to 5 (very high affect) is used and transformed to relative importance index (RII) as follows:

$$RII = \frac{\sum W}{A * N}$$

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. (Rana, 2017)

5.1.3 Ranking Index

Table 2 Ranking index of unsafe act and unsafe condition

Sr. No.	Unsafe act and unsafe condition	RII	Rank
1.	Working at elevated place	0.867	1
2.	Improper earthing	0.617	15
3.	Working on lines without taking proper safety precautions	0.622	12
4.	Unguarded floor openings, and excavations	0.832	2
5.	Exposed live wires	0.664	6
6.	Improper illumination	0.609	16
7.	Constrained location	0.805	4
8.	Unsafe design and construction such as poor scaffolding, structure, platforms	0.654	7
9.	Working on transmission lines	0.619	14
10.	Emergency work, leading to hurried working	0.804	5
11.	Opening and closing of switches without authority or warning	0.602	17
12.	working unsafety such as throwing materials or tools at another worker	0.632	11
13.	using unsafe equipment, wrong tools for the job or using hands instead of right tools	0.580	19
14.	Operating hoists and tracks without proper communication	0.641	9
15.	Over confidence like working or live electrical equipment that could be conveniently de-energized	0.651	8
16.	Taking unsafe position or posture too close to openings and lifting in an unstable position	0.634	10
17.	Distracting, teasing, joking, quarrelling, annoying	0.528	18
18.	Failure to use recommended safety protection	0.621	13
19.	Avoiding the use of guard rails and safety nets while working on higher stories	0.829	3

Table 3 Ranking index of Reasons for the accidents and injuries in construction project

Sr. No.	Reasons for the accidents and injuries in construction project	RII	Rank
1.	Working overtime	0.499	20
2.	Focus on time and cost rather than safety	0.674	11
3.	Inherent risk of construction	0.649	14

4.	Tiredness/Fatigue	0.520	19
5.	Smoking on site	0.489	21
6.	Use of mobile phone	0.457	22
7.	Lack of knowledge of site rules	0.659	12
8.	Poor construction planning	0.775	6
9.	Space congestion	0.684	9
10.	Unsafe act/ violations/ non-compliance behaviour	0.683	10
11.	Lack of safety in design	0.827	3
12.	Lack of competency	0.694	7
13.	Inadequate procedures	0.632	17
14.	Inadequate maintenance of tools and equipment	0.635	15
15.	Communication issues	0.634	16
16.	Lack of management commitment	0.654	13
17.	Ignorance of PPE (Personal Protective Equipment)	0.847	1
18.	Poor management practices	0.689	8
19.	Inadequate training	0.817	4
20.	Drugs and alcohol	0.793	5
21.	Loading, unloading and transportation of loads	0.617	18
22.	Poor accidents reporting systems	0.829	2

5.1.4 Critical Factors

Table 4 Critical factors of unsafe act and unsafe condition

Working at elevated place
Unguarded floor openings, and excavations
Avoiding the use of guard rails and safety nets while working on higher stories
Constrained location
Emergency work, leading to hurried working

Table 5 Critical factors of reasons for the accidents and injuries in construction project

Ignorance of PPE (Personal Protective Equipment)
Poor accidents reporting systems
Lack of safety in design
Inadequate training
Drugs and alcohol

5.1.4 Mitigation Technique

Several mitigation techniques have to be proposed for the above-mentioned critical factors, in order to ensure a safe working environment by avoiding hazardous situations. Following methods have been proposed to minimize or avoid these hazards by certain mitigation techniques.

Working at elevated place: For working at elevated place the following mitigation techniques are used.

Good Design: Good design is essential when working in an elevated position. Not only of the existing structure or materials to be worked on, but also of the design and strength/stability of the access equipment used, as well as the task itself.

Work supervision and planning: When working at heights, initial plans should be made with careful consideration and the use of good working equipment. A safe mechanism of work should be set up or initiated which takes in to consideration the following: Equipment, such as fall arrest equipment, must be supervised. Weather conditions, such as working in the rain on a slippery surface. It is important to have emergency or rescue plans in place.

Work avoidance in adverse weather conditions: If adverse weather conditions, such as rain or wind, increase the risk of working at height.

Main Precautions:

Avoid working at heights without a safety belt. Guardrails that are strong enough to prevent a fall are provided on a safe working platform. Provide properly installed personnel equipment such as rope access or boatswain's chairs where a safe work platform is not possible.

Unguarded floor openings and excavations:

Excavation, cavity or trench is a manmade cut in the ground made by removing earth. construction of trench is the most common form of excavation.

For house foundation or basement excavation following condition are follow:

1. The excavation for the house foundation should be no deeper than 7.5 feet.
2. Every 5 feet of depth and at least 2 feet horizontally, excavating should be benched.
3. The excavation's minimum horizontal width at the bottom should not be less than 2 feet.
4. At the excavation site, there should be no water surfaces, cracks, or other conditions that could compromise the excavation's stability.
5. All excavation equipment, materials, and loose soil should be kept at least as far back from the excavation's edge atleast equal to the depth of the excavation.
6. Work in the excavation should be performed by a minimum number of workers.

Avoiding the use of the guard rails and safety nets while working on higher stories:

Use of guard rails and safety net while working on higher stories. Because it is important safety equipment.

These following steps can help avoid slips/falls:

1. Build and design facilities with non-slip flooring.
2. Keep the floor dry and clean.

3. It is important to repair leaking pipes.
4. Use mats to track liquids.
5. Consider slips and falls when analysing the tasks.
6. Adequate lighting should be provided.
7. Slip resistant shoes should be provided.
8. Discarded tools, projecting parts, or garbage.
9. Locate rainwater or liquids from a leaking pipe.

Constrained location: For constrained location the following mitigation techniques are used.

1. Management survey: Construction managers should identify all confined spaces. Because many workers do not work in hazardous environments that are obvious to a trained safety professional.
2. Inspection: Inspection should be performed prior to the start of work and should also determine whether worker entry into a confined space is absolutely necessary.
3. Identify all hazards: Identify all hazards associated with the confined space.
4. Job hazard analysis: Before entering a confined space, a job hazard analysis for each task must be performed, which will explain every step to be taken and what procedures are required.
5. Communication with the worker: Communication between the worker in the confined space and the person on the other side of the confined space.
6. Appropriate rescue system: Trained rescue system should be present in site.

Emergency work leading to hurried working: The hazards in construction are also lead by one such reason i.e. hasty working methods under emergency conditions. In an emergency situation, hasty working conditions are caused by the following reasons:

1. Initial safety measures were not provided, which resulted in the emergency.
2. The use of emergency equipment to deal with a situation that causes pave and hurried work among the workers, such as a lack of sand buckets in a fire-affected area, can result in pains.

Ignorance of PPE: PPE is essentially anything you can wear to protect yourself from potentially hazardous conditions. PPE is important because it prepares you for possible health and safety hazards and provides additional protection in the event of an accident or against the elements.

Without PPE, employees are at risk of:

1. Being hit by falling objects or debris.
2. Impacts and collisions.
3. Breathing in contaminated air.
4. Cuts and punctures.
5. Chemical burns.

6. Electric shocks.
7. Exposure to excessive noise or vibration.

The following forms of PPE should be worn on site to avoid accident:

1. **Hard hat:** Hard hats and helmets can protect workers from being hit in the head or from being electrical hazards.
2. **Fall protection:** Even if a worker is working five to ten feet off the ground, fall protection can save their life.
3. **Safety gloves:** It is essential that construction safety gloves are snug and appropriate for the task at hand. For example, if a worker is working near electricity, they should be given insulated gloves, whereas a worker doing concrete work should be given rubber gloves.
4. **Boots:** Boots should be essential to every construction site. These kinds of boots are non-slip, puncture resistant, and usually either steel or safety-toed.
5. **Hearing protection:** Whether the construction site is filled with noisy machines or next to a loud freeway, it is important to provide hearing protection to reduce the chance of permanent hearing damage. If hearing PPE will need to be used often, there are ear muffs that easily clip onto a hard hat and have pivot points to ensure comfort for the wearer.
6. **Eye protection:** Construction sites can have things often flying around or tools with dust coming up, so it is important to provide appropriate safety goggles or glasses to workers. There are many different varieties of eye protection, ranging from glasses with anti-fog technology to goggles with a built-in face shield.

Poor accident reporting systems: The purpose of an accident reporting system is to uncover the circumstances and conditions that led to an event to help prevent similar future incidents in the future.

Prevention:

1. Record the accident to ensure that accident should not be repeated.
2. The records should include details regarding the incident or disease,
3. The record should include personal details of the individual involved.
4. The record should include the time and place of the event.
5. Enter the number of days the injured or ill worker was away from work or was on job transfer or restricted work activity.
6. Identify whether the case is an injury or illness. If the case is an injury, check the injury category. If the case is an illness, check the appropriate illness category.
7. Submitted above all the information to the higher authority.

Lack of safety in design: A safe design approach results in many benefits including: prevent injury and disease. Improve usability of products, systems and facilities. Improve productivity.

Precautions:

1. **A change in designer mindset:** Designers should realize the fact that their effort can enhance the workers safety.
2. **Motivated designers:** Many design professionals require better motivations that benefits to worker's safety. Design contract, information on cost savings potential, professional ethical codes, construction codes, regular design practices and legal actions are examples of motives.
3. **Knowledgeable designers:** Designers should be trained on safety-related issues during their university education; design suggestions database should be provided for them so they can implement design alternatives to improve worker's safety on sites.
4. **Constructor involvement:** Communication between constructors, construction workers, and designers can assist designers in identifying site hazards which allows designers to modify design features that improves worker's safety.

Inadequate training: When there is no training, employees do not understand how to do their jobs and none of these goals are possible. This leads to low morale among workers, which results in Accidents.

Prevention:

1. Conduct a training before the execution to avoid accidents.
2. After to recruitment, company should give compulsory training to all the freshers.
3. Find all the hazards and cover it on training session to avoid injuries.
4. Give training about the correct procedure of particular activity.
5. By using the technology, show virtual training videos in training session.
6. Also, give training on how to handle the equipment and materials.

Drugs and alcohol: Drug and alcohol abuse increase the dangers further, leading to an increase in workplace accidents and possible fatalities. The slightest lapse in attention or focus can cause serious consequences, especially where heavy machinery and vehicles are being used or when working up high. The most common influences that can affect an individual in a working environment are:

1. Reduced awareness, including vision and hearing.
2. Reduced concentration and ability to focus.
3. Diminished judgement and decision making.

4. Compromised balance and bad co-ordination.

Prevention:

1. Implementing drug and alcohol testing to all employees within the construction industry can seriously decrease the levels of drug and alcohol misuse in the workplace.
2. Motivate them during the training to not consume drugs and alcohol.
3. Stick the sign board of prohibition of drugs and alcohol on site.

5.2 Simulation-based Model

Simulation based model is prepared to indicate the various safety equipment, which can reduce the loss of property and can rescue the people easily. The following Safety equipment are shown in below figures:



Fig 6 Fire extinguisher and Water sprinkler



Fig 7 Fire Protective Curtain



Fig 8 Emergency Exit and Fire Alarm

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The analysis of the collected data and a comparative study of the available literatures assisted in the identification of 9 unsafe acts and 10 unsafe conditions. Also, 22 reasons of accidents and injuries that have an impact on Indian projects have been identified. The results from the thesis conclude the 10 critical factors in the field of building construction i.e. working at elevated place, avoiding the use of guard rails and safety nets while working on higher stories, confined space, unguarded floor openings and excavations and emergency work leading to hurried working, lack of safety in design, ignorance of PPE (Personal protective equipment), inadequate training, Consumption of drugs and alcohol, poor accident reporting system. Mitigation techniques were proposed for the above found 10 critical factors to minimize the hazards caused by them on construction sites. The study shows that proper remedies and measures should be taken in every construction site to prevent any chance of occurrence of any kind of accidents. And government should play a more critical role in safety of construction industry.

6.2 Future Scope

Further factors can be identified through literature review and data collection through ongoing projects. Case studies of on-going projects can be reviewed to identify different other factors. The focus of the thesis was on the hazards caused due to unsafe act, unsafe conditions and other reasons on the construction sites. Also, this research can be helpful to construction industry to prevent the accidents.

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