

# Evaluating Factors affecting Safety Performance of Construction Firms

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**Abstract**— In both developed and developing countries, the construction industry is considered to be one of the most significant industries in terms of its impact on health and safety of the working population. Construction industry is both economically and socially important. However, the construction industry is also recognized to be the most hazardous. The Objectives of this research are to investigate the safety performance in the construction sites. The study will be conducted in construction sites in Nashik city through method of questionnaire survey, interview and discussion. The data were collected from the contractors and owners by using questionnaire to evaluate the safety performance in the construction sites. In total, 25 companies were considered for data collection. The results show that there was still a lack of commitment from the top management, the insurance company, the labour ministry, the owners, and also the contractors to improving safety performance on the construction sites. The suggestion is to improve the safety performance on the construction sites. The government should follow up the safety performance by visiting the construction sites. The insurance company should be more active in visiting the construction sites. The owners should be more active towards the safety by controlling, visiting the process in the construction sites. The contractors have to train the workers and promote the safety culture and follow up the safety performance. The consultants should control all the tools in the construction sites to insure that those tools are safe.

**Key words:** Factors Affecting Safety Performance, Safety in the Construction Industry

## I. INTRODUCTION

In the developed as well as developing part of the world, construction industry is considered to be one of the most significant industries in terms of its impact on health and safety of the working population. Construction industry is both economically and socially important. However, the construction industry, at the same time, is also recognized to be the most hazardous. Although dramatic improvement has taken in recent decades; the safety record in the construction industry continues to be one of the poorest.

Safety is a condition of being safe, freedom from danger or hazards, a keeping of oneself or others safe, especially from danger of accidents or disease. Safety is the state of being "safe", the condition of being protected against physical, social, spiritual, financial, political, emotional, occupational, psychological, educational or other types or consequences of failure, damage, error, accidents, harm or any other event which could be considered non-desirable. Safety can also be defined to be the control of recognized hazards to achieve an acceptable level of risk. This can take the form of being protected from the event or from exposure to something that causes health or economical losses. It can include protection of people or of possessions.

Safety management concerns the improvement in health conditions at workplace and reducing a sort of costs emanating from work accidents that could be originated by inadequate working environment, insufficient informing and low consciousness level of employees or lack of attention.

The prevention of construction accidents usually entails predicting future accidents and their nature under given circumstances. The making of such predictions is based on knowledge about past accidents. Due to the fact that accident rates in construction are high when compared to other industries, the construction and projects managers need to be fully prepared to deal with accidents when they occur, undertaking proper investigations and reporting procedures afterwards. Accident statistics represent not only terrible human tragedies but also substantial economic costs. This is because accidents cause damage to plant equipment and the loss of productive work time until the normal site working rhythm and morale are restored. Accidents can also cause work disruption and reduce the work rate.

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 result in unsafe work methods, equipment and procedures. Construction safety on project sites is of utmost importance due to the nature of the construction industry. However, it is usually a secondary concern in a market-driven society where the main concern is completing projects at the required quality with minimum time and cost. Thus, safety issues are considered only after an accident occurs at a construction site with follow up measures to improve working conditions, especially in developing countries. Safety describes the surety that the environment that personnel or items are subjected to, is free from in advertent or unexpected events which may result in injury to personnel or damage to the items exposed.

Hence, it is important to maintain safe environment on construction site to reduce accidents also the safety performance on construction site will lead to improve working conditions on site.

Thus, construction companies have to consider these factors, and develop appropriate strategies to avoid failure.

## II. NEED OF THE STUDY

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.

The study provides information about factors affecting safety performance of construction site and the safety measures adopted by the companies also to make the employees aware of the safety norms and procedures of their companies. In a country like India, safety is all the more important because of lack of social security to the family left behind. Thus, it becomes necessary to consider factors affecting safety performance of construction project to prevent accidents.

### III. PROBLEM STATEMENT

The concept of construction site safety has been widely accepted as a crucial issue in the construction industry of India in recent years. The general aim of the research is to find ways for further improving construction site safety at the construction projects. So, data collected from various construction firms & analyzed using SPSS Method.

### IV. METHODOLOGY

The methodology of the work consisted of the following steps:

- 1) After selecting the topic the first stage of the project work is to define the aim of the study and to highlight the problems statements and establishment of clear objectives specified within the project work plan.
- 2) The second step of the project work included a summary of the comprehensive literature review. Literatures on safety performance were reviewed. The factors and sub factors affecting safety performance were identified.
- 3) The third step includes identifying the factors affecting safety performance in construction projects in Nashik region by visiting to construction site particularly from Nashik region by discussing with safety manager.
- 4) The fourth step is focused on the data collection for SPSS. For this a questionnaire is designed considering the identified safety factors to collect the required data and it is distributed targeting the contractors/ safety engineers of the 40 construction project.
- 5) The fifth step of this work is the analysis of the obtained data from 25 construction projects. Statistical Package for the Social Sciences, (SPSS) was used to perform the required analysis and the ranking is given to the factors accordingly.

The final phase includes the conclusions and recommendations for the other construction projects to improve their safety performance.

No	Main Factors and Sub factors
1	Project Nature
1.1	Volume of the project
1.2	Cost of the project
1.3	Arrangement and organization the site (Tide site)
1.4	Planning and scheduling of the project
1.5	Application of new technology in construction projects
1.6	Type of the owner ( Owner identify)
1.7	Clear and easy of project's design
1.8	Lighting the site during night working hours
2	Emergency Planning and Preparations
2.1	Develop a plan to respond to emergencies
2.2	Training workers to respond to emergencies

	through the exercises
3	Signs, Signals and Barricades
3.1	The use of danger signs
3.2	The use of caution sign
3.3	The use of instruction signs
3.4	The use of traffic signals in site
3.5	The use of barricades to close the site for the pedestrians
4	Historic, Human and Psychological Climate
4.1	Worker age
4.2	Worker experience
4.3	Worker education
4.4	Worker culture background
4.5	Worker marital status
4.6	Worker safety training received
4.7	Worker safety awareness, knowledge & involvement
4.8	Worker accident's experience
4.9	Worker's ability to communicate with others
4.10	Relation between the management and workers in the site
4.11	Relation between the supervisor and workers in the site
4.12	Interrelation between the workers in the site
4.13	Decrease work pressure on workers
4.14	Non-excessive overtime work for worker
5	Welfare Facilities
5.1	Provision of food and drinking water
5.2	Provision of adequate facilities for first aid treatment
5.3	Provision of an ambulance in the site
5.4	Provision of adequate toilets
6	Administrative and Management Commitment
6.1	Safety awareness of company's top management
6.2	Safety awareness of project managers
6.3	Availability a clear company's safety policy
6.4	Issuing and implementation of in-house safety rules, safety program or manuals
6.5	Conduction of safety policy review
6.6	Management's attitude towards worker's welfare
7	Safety Inspections
7.1	Safety inspections by government (Ministry of Works and Municipalities)
7.2	Safety inspections by top management
7.3	Safety inspections by insurance companies
8	Safety Meetings
8.1	Conducting safety meeting in the site by the site engineer
8.2	Conducting safety meeting before beginning for each activity
8.3	Attendance of safety meetings by top management
9	Role of Government & Engineering Societies
9.1	Issuing laws, standards, regulations & legislations of safety
9.2	Strict implementation of safety instructions
9.3	The punishment in case of violation of laws, standards, regulations & legislations of safety
10	Crane and Lifting Equipment
10.1	Selection of licensed operator who having skill and efficiency

10.2	Enforce limited amount weights to be lifted by crane with stickers shows limits
11	Safety Educating & Training
11.1	Guidance and training of workers to safety
11.2	Brochures and publications on safety
11.3	Safety seminars held by the management of the project
11.4	Safety poster
11.5	Training of first aid for all workers
12	Disposal of Hazardous Materials and Waste
12.1	Develop a risk management plan
12.2	Develop a waste management plan
12.3	Quick transfer of construction waste out the site
13	Personal Protective Equipment
13.1	The use of protective head
13.2	The use of protective feet
13.3	The use of gloves and face protection
14	Excavation, Trenching, and Shorting
14.1	The use of barricades to prevent collapse of soil during work
14.2	Soil type in terms of coherence
14.3	Low level of groundwater below the excavation areas
15	Scaffolds
15.1	Design of scaffolds as international specifications (OSHA for example)
15.2	The type of material made of scaffolds
15.3	Correct using of scaffolds
16	Fire Prevention
16.1	Availability of adequate fire extinguishers in the site
16.2	Good storage of flammable liquids and combustible materials
16.3	Periodical maintenance of fire extinguishers which located in the site
17	Transportation
17.1	Periodical maintenance for vehicles and machinery (Trucks, Loaders...etc.)
17.2	Wearing seat belts during drive vehicles and machinery
17.3	Training drivers of vehicles and machinery
18	Economic Investment
18.1	Allocating specific budget for safety requirements
18.2	Financial motivation to application of safety
18.3	Agreement with insurance companies
19	Medical Facilities
19.1	Permanent presence of a medical specialist in the site
19.2	Availability of medical apparatus in the site
19.3	Periodical medical examination of workers

Table 1: Factors affecting safety performance

#### A. Statistical Package for the Social Sciences (SPSS)

SPSS Statistics is a software package used for statistical analysis. Long produced by SPSS Inc., it was acquired by IBM in 2009. The current versions (2015) are officially named IBM SPSS Statistics. Companion products in the same family are used for survey authoring and deployment (IBM SPSS Data Collection), data mining (IBM SPSS Modeller), text analytics, and collaboration and deployment (batch and automated scoring services).

The software name originally stood for Statistical Package for the Social Sciences (SPSS), reflecting the original market, although the software is now popular in other fields as well, including the health sciences and marketing.

Statistical analysis can be conducted using two main methods. One is simply by using a generalized spread sheet or data management program such as MS Excel or through using a specialized statistical package such as SPSS. Here are key reasons why SPSS is the best option to use.

SPSS is a widely used program for statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others. The original SPSS manual (Nie, Bent & Hull, 1970) has been described as one of "sociology's most influential books" for allowing ordinary researchers to do their own statistical analysis. In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation (a metadata dictionary was stored in the data file) are features of the base software.

Statistics included in the base software:

- Descriptive statistics: Cross tabulation, Frequencies, Descriptive, Explore, Descriptive Ratio Statistics
- Bivariate statistics: Means, t-test, ANOVA, Correlation (bivariate, partial, distances), Nonparametric tests
- Prediction for numerical outcomes: Linear regression
- Prediction for identifying groups: Factor analysis, cluster analysis (two-step, K-means, hierarchical), Discriminant

Statistical output is to a proprietary file format (\*.spv file, supporting pivot tables) for which, in addition to the in-package viewer, a stand-alone reader can be downloaded. The proprietary output can be exported to text or Microsoft Word, PDF, Excel, and other formats. Alternatively, output can be captured as data (using the OMS command), as text, tab-delimited text, PDF, XLS, HTML, XML, SPSS dataset or a variety of graphic image formats (JPEG, PNG, BMP and EMF).

#### B. Benefits of SPSS

##### 1) Effective data management

While it is spot on that a spread sheet program offers more control with regards to the data organization, this can also be seen as a demerit. In contrast, you cannot move data blocks in SPSS as it is meant for organizing data in an optimal manner. A row represents one case, whereas a column denotes one variable. SPSS makes data analysis quicker because the program knows the location of the cases and variables. When using a spread sheet, users must manually define this relationship in every analysis.

##### 2) Wide range of options

SPSS is specifically made for analysing statistical data and thus it offers a great range of methods, graphs and charts. General programs may offer other procedures like invoicing and accounting forms, but specialized programs are better suited for this function. SPSS also comes with more techniques of screening or cleaning the information in preparation for further analysis. Furthermore, normal spread sheet programs may only support data analysis immediately

following installation, with extra plug-ins being required for accessing more intricate techniques.

3) *Better output organization*

SPSS is designed to make certain that the output is kept separate from data itself. In fact, it stores all results in a separate file that is different from the data. However, in programs like Excel, results of an analysis are placed in one worksheet and there is a likelihood of overwriting other information by accident.

C. Steps to Find Mean and Standard Deviation in SPSS

Following are the steps to calculate mean and standard deviation in Statistical Package for the Social Sciences (SPSS).

1) *Step 1: Entering and saving Data.*

Prepare a work sheet showing data collection from the owner and contractor.

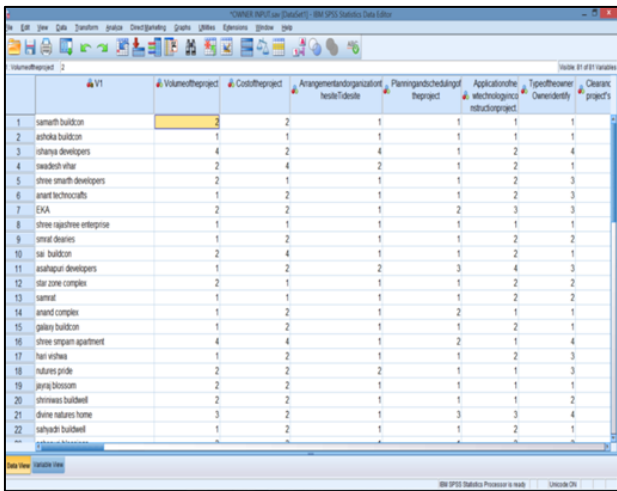


Fig. 1: Data entry in SPSS

a) Step 2: analyse the data using descriptive statistics: In SPSS, mean and standard deviation is computed by choosing

- Analyze
- Descriptive
- Statistics
- Descriptive

Click on the Analyze menu and choose Descriptive Statistics then Descriptive.

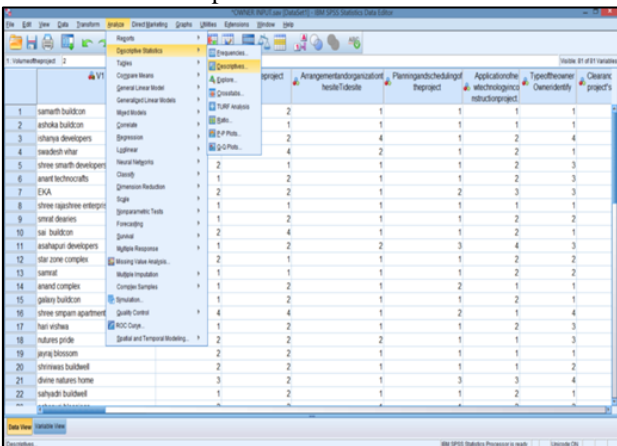


Fig. 2: data analysed with descriptive statistics

2) *Step 3: enter the variables to be analysed*

We first select the desired variables from the field on the left by moving them to the right

The button between the two windows let you choose the variables to be analyzed, in our case, just click the center button to move the first factors variable over to the right then click OK.

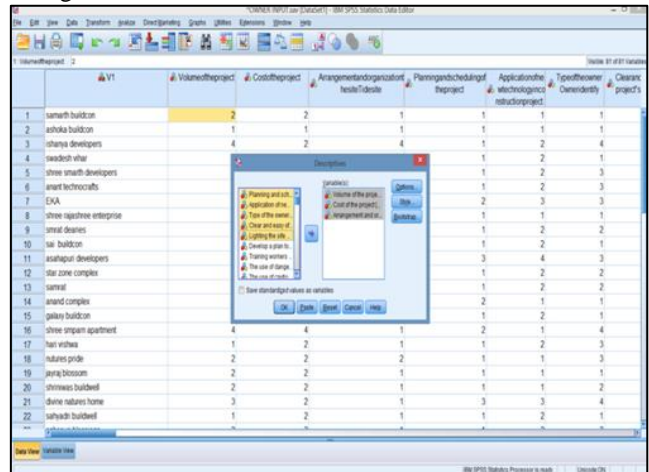


Fig. 3: Data Entered according to the groups

Then, we click on the Options button to determine which statistics should be computed.

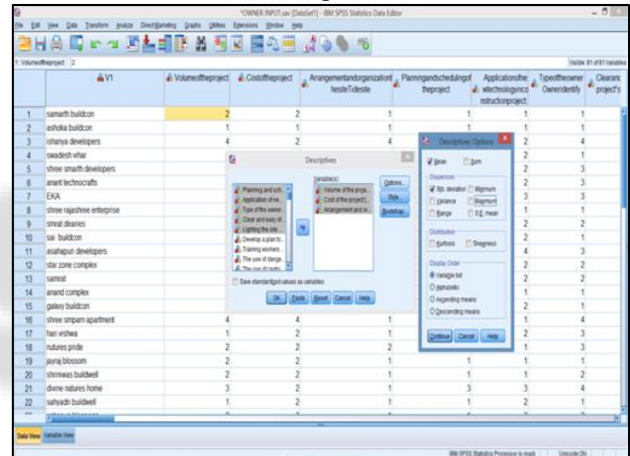


Fig. 4: Requirements of the output are defined

3) *Step 4: create output*

These options, then, generate the following output. You will see from the output that the “Descriptive” option gives you a statistical description of the data. It tells us how many cases there are (N=25) the Maximum, Minimum, a form of average called the Mean and a more complex statistic called the Standard Deviation, this last one gives us a numerical indication of how spread out the data are.

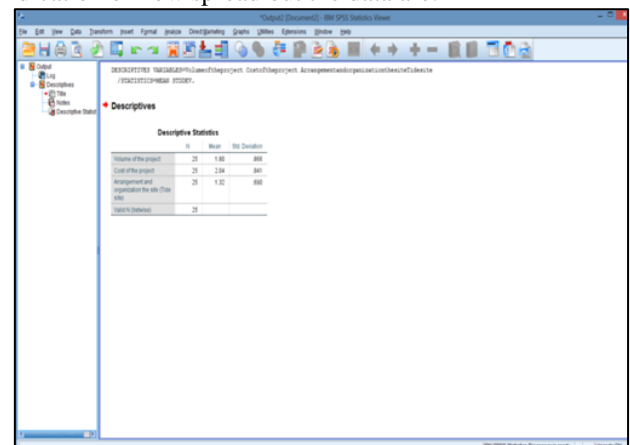


Fig. 5: Output File is generated

V. RESULT

The data collected from safety engineers/contractors of 25 construction firms are analysed using SPSS method. The mean and standard deviation of the safety factors are calculated. The rank for each factor was determined by considering these mean and standard deviation values computed from the respondents' data.

The rank was provided according to the lower mean value, if both the mean values are equal then we considered the higher standard deviation value is taken as higher rank. The values of Mean, Standard Deviation (Std. Dev.) and Ranks of the main and sub factors are summarized in following tables.

Sr. No.	Main Factors and sub factors	Mean	Std. Dev.	Rank
1	Personal Protective Equipment	1.154	0.368	1
2	Signs, Signals and Barricades	1.313	0.602	2
3	Safety Meetings	1.615	0.650	3
4	Safety Inspections	1.731	0.724	4
5	Administrative and Management Commitment	2.077	0.744	5
6	Safety Educating & Training	2.423	0.902	6
7	Project Nature	2.731	0.724	7
8	Economic Investment	2.840	0.925	8
9	Fire Prevention	2.880	0.849	9
10	Medical Facilities	2.962	0.958	10
11	Excavation, Trenching, and Shorting	3.000	1.058	11
12	Crane and Lifting Equipment	3.038	1.148	12
13	Scaffolds	3.192	1.021	13
14	Role of Government & Engineering Societies	3.231	1.070	14
15	Historic, Human and Psychological Climate	3.308	0.970	15
16	Disposal of Hazardous Materials and Waste	3.346	0.892	16
17	Emergency Planning and Preparations	3.538	0.859	17
18	Transportation	3.654	1.129	18
19	Welfare Facilities	3.769	0.815	19
Project Nature				
1	Arrangement and organization the site (Tide site)	1.44	0.583	1
2	Lighting the site during night working hours	1.52	0.823	2
3	Planning and scheduling of the project	1.68	0.627	3
4	Volume of the project	1.76	0.879	4
5	Application of new technology in construction projects	1.76	0.779	5
6	Type of the owner ( Owner identify)	2.08	1.077	6
7	Clear and easy of project's design	2.08	0.909	7
8	Cost of the project	2.08	0.862	8
Emergency Planning and Preparations				
1	Develop a plan to respond to	1.68	0.627	1

emergencies				
2	Training workers to respond to emergencies through the exercises	1.68	0.476	2
Signs, Signals and Barricades				
1	The use of caution sign	1.4	0.500	1
2	The use of barricades to close the site for the pedestrians	1.44	0.583	2
3	The use of danger signs	1.48	0.586	3
4	The use of instruction signs	1.68	0.802	4
5	The use of traffic signals in site	1.68	0.627	5
Historic, Human and Psychological Climate				
1	Worker safety training received	1.64	0.638	1
2	Worker experience	1.8	0.764	2
3	Worker safety awareness, knowledge & involvement	1.84	0.943	3
4	Relation between the supervisor and workers on the site	1.92	0.862	4
5	Worker accident's experience	2.08	0.909	6
6	Worker age	2.12	0.833	7
7	Interrelation between the workers in the site	2.16	1.106	8
8	Non-excessive overtime work for worker	2.24	0.879	9
9	Worker's ability to communicate with others	2.24	0.779	10
10	Relation between the management and workers on the site	2.28	0.843	11
11	Worker education	2.32	1.069	12
12	Decrease work pressure on workers	2.56	1.044	13
13	Worker culture background	2.64	1.186	14
Welfare Facilities				
1	Provision of adequate facilities for first aid treatment	2.04	0.735	1
2	Provision of an ambulance in the site	2.2	0.764	2
3	Provision of food and drinking water	2.28	0.891	3
4	Provision of adequate toilets	2.32	1.282	4
Administrative and Management Commitment				
1	Conduction of safety policy review	1.6	0.500	1
2	Issuing and implementation of in-house safety rules, safety program or manuals	1.64	0.995	2
3	Safety awareness of project managers	1.64	0.638	3
4	Management's attitude towards worker's welfare	1.72	0.678	4
5	Availability a clear company's safety policy	1.72	0.542	5
6	Safety awareness of company's top management	1.76	0.523	6
Safety Inspections				

1	Safety inspections by top management	1.52	0.510	1
2	Safety inspections by government (Ministry of Works and Municipalities)	1.76	0.663	2
3	Safety inspections by insurance companies	2	0.957	3
<b>Safety Meetings</b>				
1	Conducting safety meeting in the site by the site engineer	1.36	0.490	1
2	Conducting safety meeting before beginning for each activity	1.56	0.583	2
3	Attendance of safety meetings by top management	1.84	0.688	3
<b>Role of Government &amp; Engineering Societies</b>				
1	Strict implementation of safety instructions	1.76	0.597	1
2	Issuing laws, standards, regulations & legislations of safety	2	0.816	2
3	The punishment in case of violation of laws, standards, regulations & legislations of safety	2.48	0.918	3
<b>Crane and Lifting Equipment</b>				
1	Enforce limited amount weights to be lifted by crane with clear stickers shows the limits	2.08	0.909	1
2	Selection of licensed operator who having skill and efficiency	2.08	0.862	2
<b>Safety Educating &amp; Training</b>				
1	Training of first aid for all workers	1.64	0.569	1
2	Guidance and training of workers to safety	1.72	0.458	2
3	Brochures and publications on safety	1.88	0.526	3
4	Safety seminars held by the management of the project	1.88	0.440	4
5	Safety poster	2.04	0.676	5
<b>Disposal of Hazardous Materials and Waste</b>				
1	Develop a risk management plan	2.04	0.539	1
2	Quick transfer of construction waste out the site	2.2	1.000	2
3	Develop a waste management plan	2.28	0.843	3
<b>Personal Protective Equipment</b>				
1	The use of protective feet	1.36	0.569	1
2	The use of protective head	1.44	0.712	2
3	other PPE for specialized work	1.68	0.690	3
4	The use of gloves and face protection	1.8	1.000	4
<b>Excavation, Trenching, and Shorting</b>				
1	The use of barricades to prevent collapse of soil	1.76	0.723	1

<b>during work</b>				
2	Soil type in terms of coherence	2.12	0.726	2
3	Low level of groundwater below the excavation areas	2.24	0.970	3
<b>Scaffolds</b>				
1	The type of material made of scaffolds	1.8	0.577	1
2	Correct using of scaffolds	2.04	0.841	2
3	Design of scaffolds as international specifications (OSHA for example)	2.16	1.106	3
<b>Fire Prevention</b>				
1	Good storage of flammable liquids and combustible materials	1.64	0.569	1
2	Periodical maintenance of fire extinguishers which located in the site	1.92	0.759	2
3	Availability of adequate fire extinguishers on the site	1.92	0.702	3
<b>Transportation</b>				
1	Training drivers of vehicles and machinery	1.84	0.746	1
2	Wearing seat belts during drive vehicles and machinery	1.84	0.688	2
3	Periodical maintenance for vehicles and machinery (Trucks, Loaders, Shovel...etc.)	1.92	0.702	3
<b>Economic Investment</b>				
1	Allocating specific budget for safety requirements	1.92	0.572	1
2	Agreement with insurance companies	2.04	0.611	2
3	Financial motivation to application of safety	2.08	0.493	3
<b>Medical Facilities</b>				
1	Availability of medical apparatus in the site	1.88	0.526	1
2	Permanent presence of a medical specialist in the site (Availability of medical advice)	2	0.707	2
3	Periodical medical examination of workers	2.04	0.611	3

Table 2: Combined Results of All 25 Construction Projects

## VI. CONCLUSION & RECOMMENDATION

Safety practices and scenario of Indian construction industry and the safety management of the construction industry particularly for Nashik city were studied. From literature survey eighty factors were identified which are grouped into nineteen groups and finalized the factors by considering local conditions particularly to Nashik region for further study.

The data is collected from the 25 construction companies located in Nashik city by rating each safety factors by owners and contractors through questionnaires survey. The gathered data through the questionnaires were statistically analyzed using SPSS software and the mean and

standard deviation of each factor is calculated. From the output of SPSS analysis the factors were ranked according to their weightage.

The result of this study reveals the factors which are the responsible for safety non-performance of construction firms and also the safety level of construction firms in and around Nashik region. For the implementing safety and increasing safety performance of the construction project the suggestion and recommendations are given which helps in create the safety management awareness to construction firms.

Based on the conclusions identified previously, and the results obtained from this research, the following points can be recommended:

- It is recommended to strengthen the awareness and attitude of the top management and project managers towards the importance of safety. The managements of the company must establish and enforce safety polices for workers and should develop their activities by including more monitoring of safety performance at the site and by giving more reliable feedback about the consequences that take place. Companies should hold their project management accountable for accidents.
- It is recommended for the concerned government authorities to hire qualified, competent and certified engineers to conduct regular site inspections.
- It is recommended for the company's management to conduct clear safety policy and periodically random safety inspections for technical works like, fire prevention, crane lifting and scaffolding as to ensure the implementation of safety provisions and conditions.
- It is recommended to increase the efficiency of site safety inspections by using more qualified safety engineer with specific job description.
- It is recommended to conduct formal safety meetings with all parties, such meetings are necessary for communicating safety information to all parties. Special meetings can be conducted before each new activity begins.
- It is recommended that only experienced workers should be allowed to perform risky tasks, especially when using heavy machinery or powered tools and drive should be provided for new workers since they are the ones who are exposed to the danger of daily job hazards.
- Emphases should be laid on investigation the indirect costs of accidents. These costs in addition of being greater than the direct costs, which are usually covered by insurance, they buried into project costs, increasing the cost of construction. The costs of accidents present a serious drain of company's profit. Therefore more attention will be paid to the economic investment in safety if the contractor realizes the fact that the costs of accidents are higher than the cost of safety.
- It is recommended for the company to implement a system for safety incentive for the workers. It may not necessarily be the best tool to enhance safety performance of work site, but some form of incentive is important.
- The concept of safety, in its broadest sense, should be taught in all stage of education. All media should pay attention to safety rules in all fields.

- The owners and the engineer should enforce the contractor to comply with the safety requirements.
- The quantitative appraisal of safety performance should be applied for construction companies to permit comparing different companies performances.
- Awareness campaign should be established to widen up the understanding of such signs and the importance of using it in various construction building, roads and water sewage projects.
- Safety documents should enclose the safety measures and the signs ought to be used during implementation. Clients should be tight in applying the safety measures and the no. of signs to be used during the implementation phase of any project.

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