EVALUATION OF THE SAFETY PERFORMANCE LEVEL OF CONSTRUCTION PROJECTS IN GUJARAT

Pranav Patel[1], Dr. Rajiv Bhatt[2], Dr. Jayeshkumar Pitroda[3]

[1] *Student of Final Year, M.E. (Construction Engineering & Management), B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat, India*

[2] *Associate Professor, Civil Engineering Dept., B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat, India*

[3] *Assistant Professor, Civil Engineering Dept., B.V.M. Engineering College, New Vallabh Vidyanagar, Gujarat, India*

ABSTRACT

In Gujarat, the growth of construction industry development is comparatively higher than any other industries. But the safety level of construction industry is quite lower than any other industries. As the construction industry is highly labor intensive, employees around 10 million people and the rate of workplace fatal accidents in construction sector is four to five times than that of the manufacturing sector so the issue of safety assumes importance. Construction project sites are often full with probable hazards that lead towards serious injury or death. Occupational safety in the construction industry is very poor in developing countries. The main objective of this study is to evaluate the safety performance level of construction projects. For this a comprehensive literature from concerning various literatures was deployed to find the factors affecting on project performance. The founded factors was categorized in eight categorized like self-protection, housekeeping, scaffolding, access to height, organizational, first aid, fire protection and general category. Questionnaire survey was held in three cities of Gujarat and total 197 questionnaire was distributed to various project stakeholders like developer, contractor and project managers. Out of the total distributed questionnaire 153 questionnaire was useful. During the site visits it was noticed that due to awareness, lack of safety training, lack of safety training, lack of safety promotion, and lack of documented and organized safety management systems the performance level is very lower then developed countries a project level. The outcome of questionnaire survey and site visits describes that most of projects running between extremely unsafe to unsafe level.

Keyword: - *Construction Safety, Developing countries, Safety Performance, Performance Index*

1. INTRODUCTION

Today construction industry is become integral part of GDP of any developing or developed country. Construction industry is important both economically and socially. The construction industry, at the same time also recognized to be the most hazardous and dangerous. (Suazo and Jaselskis, 1993). [10] Huang and Hinze mentioned in their studies that although dramatic improvements have taken place in recent decades, the safety records in construction industry continues to be one of the poorest. [5]. the construction industry is regarded as a dangerous industry due to its characteristics; decentralization and mobility. Decentralization means the worker of construction industry separated by site by site and no central authority for them. Though protocols and plans available, they still have facing specific problems regarding their safety and other rights. Mobility means that employees in construction industry move aside the different companies, sites and positions more frequently than traditional industries. Due to above two features, while the promotion of safety management and working condition is achieved in a manner that is used by several industries to consciously improve safety performance, they are inadequate in

construction industry. Safety performance is more important for a construction industry to improve its safety culture to achieve better safety performance at project level. A positive safety culture means the safety attitude and values of project are totally accepted by its employees.

As construction industry plays dynamic roll in GDP of developing as well as developed countries the world, the health and safety of concerning population of industry is most important. Research shows that the major causes of accidents are related to the unique nature of the industry, human behaviors, difficult work site conditions and poor safety management , which result in unsafe work methods, equipment's and procedures. Importance in both developing and developed countries need to be placed on training and the application of comprehensive safety programs.

2. OBJECTIVE OF STUDY

The principal objective of this study includes following:

1. To identify and explore the existing safety procedures, regulations, policies and employee values, attitudes and Perception about the safety climate of the construction projects.
2. To find a safety performance level of various construction projects and to understand the safety problems that occur during construction work in Gujarat.

3. LITERARTURE REVIEW

Various studies have been done to determine the factors affecting on safety performance and evaluation of the safety performance level of construction projects.

Sawacha et al. (1999) studied factors influencing safety on construction sites: historical, economical, psychological, technical, procedural, organizational and the working environment. They also summarized that the operative's expectation of their supervisor's safety attitude was relatively high and they see their superintendent's attitude towards safety as being a major source of influence upon their behavior on site, awareness of hazardous material is important than their handling, lack and training and skill are cause of accidents in technical area, use of safety equipment is important rather than availability of same, the most contributing factor is organization's policy towards safety. [8]

Choudhry et al. (2008) explained a successful, modern safety, health and environmental management system for a leading construction company and concluded useful information on eight aspects of construction safety, including safety policy and standards, safety organization, safety training, inspecting hazardous conditions, personal protection program, plant and equipment, safety promotion, and management behavior. The findings of their survey provide practical knowledge to construction project managers and construction safety practitioners in order to make their sites safer. [2]

De-chun et al. (2010) evaluated the current safety management systems in developing country (i.e. China) and prioritize these steps with the consideration of various decision criteria which can provide a useful guideline for related government agencies and project managers to focus on the safety management program, might significantly contribute to the improvement of safety record. [3]

El-Mashaleh et al. (2010) concluded the areas safety training, occasional safety meetings, occasional safety inspections, unavailability of safety protection measures, and hesitance of workers to use safety equipment, high labor turnover rates and non-compliance with safety legislation which need to improve for safety at construction sites. [4]

Laryea et al. (2010) investigated in Ghana using first hand observation construction project sites. The primary reasons are, a lack of strong institutional framework for governing construction activities, and

poor enforcement of health and safety policies and procedures. Even though Government regulatory instruments for ensuring health and safety on construction sites are set, contractors are not aware of it or do not consider it which leads to mishap at construction site and concluded that workers and civil society should ensure and demand the provision of adequate health and safety policies, procedures and provisions to govern construction work. [7]

Charehzehi et al. (2012) concluded the factors influencing in the improvement of safety performance at construction site are safety management error, poor training programs, human element, act of god, outdated procedure and no clear monitoring policy and suggests a clear procedure to develop safety performance by reducing risk and hazards. In addition, they provided the steps to enhance the safety performance at construction site by creating safety regulation, identify hazard, assess and evaluate risk, decide precaution, record findings, and updating finding in relation to the work condition. [1]

Sunindijo et al. (2013) conceptualized safety management in construction projects and concluded that the conceptual skill helps project management personnel implement safety management tasks, which in turn promotes an onsite safety climate. The implication of this research outcomes is that construction organizations should consider improving the conceptual skill of their project management personnel. [11]

4. RESEARCH METHODOLOGY

The research methodology for present study contains two stages. The first stage included a literature survey. Literature survey was carried through books, conference proceedings, articles, internet and international construction related journals. As the outcome of this phase, factors are identified which are directly affecting on safety performance on construction site. These categories are: Self-protection category, House-keeping category, Scaffolding Category, Access to height category, Organizational category, First aid category, Fire protection and other general category.

The second stage includes preparation of survey questionnaire based on five-point liker scale is used. Respondents are required to select a scale level of each item, ranging from strongly disagree (scale 1) to strongly agree (scale 5) is used. Based on review of relevant literature all the factors are categorized as given in APPENDIX 1. And findings based on observations that used to analyze the site safety performance of construction industry in Gujarat region.

5. DATA COLLECTION

The target population included civil engineering and building construction projects in selected region of Gujarat, viz. Ahmadabad, Vadodara and Surat. The owner, developer, contractor and project manager were targeted for survey. The details of various stakeholders and total numbers of them were collected through internet. All the details were considered as the size of population to choose the sample size of the study. To obtain a statistically representative sample of the population, the formula shown in eq. (1) used was used (Hogg and Tannis 2009):

$$n = \frac{m}{1+[\frac{m-1}{N}]} \quad \text{..... (1)}$$

Where n, m, and N = the sample size of the limited, unlimited, and available Population, respectively. m is estimated by eq.(2)

$$m = \frac{z^2 * p * (1-p)}{e^2} \quad \text{..... (2)}$$

Where z = the statistic value for the confidence level used, i.e., 2.575, 1.96, and 1.645, for 99%, 95%, and 90% confidence levels, respectively; p = the value of the population proportion that is being estimated; and e = the sampling error of the point estimate. Because the value of p is unknown Sincich et al. (2002) suggested a conservative value of 0.50 be used so that a sample size that is at least as large as required be obtained. By using following values:

By taking z = 1.465, p = 0.5, e= 0.1

$$m = \frac{1.645^2 * 0.5 * (1 - 0.5)}{0.1^2} = 67.65 \approx 68$$

According to the targeted city and stakeholders, the total no. of available population comprises of construction projects are as following:

Sample size of owner/developer determined as shown below:

$$n = \frac{67.65}{1+[\frac{67.65-1}{3396}]} = 66.34 \approx 67$$

Sample size of contractor determined as shown below:

$$n = \frac{67.65}{1+[\frac{67.65-1}{1225}]} = 64.56 \approx 65$$

Sample size of project manager,

$$n = \frac{67.65}{1+[\frac{67.65-1}{149}]} = 64.76 \approx 65$$

Total no of sample size = **197**

The questionnaire was distributed to various stakeholders more than the sample size requirement. Total 197 questionnaires were distributed to different respondents in selected cities of Gujarat. This study receives 159 responses from various sites, but the reposes from 51 sites were useful for calculation. The response rate (as compare to sample size=197) for this research is 79.18%.

6. DATA ANALYSIS APPROACH

The following types of approach were used to analysis of data:

Safety performance level was calculated by use of following equations.

1. Factor safety performance index:

   Based on the safety non-performance Index and Factor Performance index (FPI) were calculated using the following formula.

   Factor performance Index (FPI) = $\frac{\sum(Factor\ score \times No.of\ sites\ at\ a\ particular\ score)}{(Total\ no.of\ responces\ factor \times 5)}$

   Factor Non-Performance Index (FNPI) = 1 - FPI

2. Safety performance category analysis:

   Category wise safety Non-performance and performance indices calculated wit following formula.

$$\text{Category Performance Index (CPI)} = \frac{\sum FPI\ (of\ the\ factors\ in\ the\ category)}{No.of\ factors\ in\ the\ category}$$

$$\text{Category Non- Performance Index (CNPI)} = \frac{\sum FNPI\ (of\ the\ factors\ in\ the\ category)}{No.of\ factors\ in\ the\ category}$$

3. Safety Performance Index

The safety performance index of fifty two investigated sites has been calculated.

$$\text{Safety performance Index} = \frac{\sum(Score\ of\ safety\ non-performance\ of\ all\ factors\ for\ a\ site)}{Maximum\ score\ for\ a\ particular\ site)}$$

Where, Max. Score for a particular site = No. of factors investigated $\times$ 5

Safety non-performance Index = 1 - Safety performance Index

From the above equations of safety performance index for particular sites was calculated and the level of performance based on results categorized as mentioned in following table.

Table 1: Safety Performance Level

%SPI	0-20%	>20-40%	>40-60%	>60-80%	>80-100%
Safety Performance Level	Extremely Unsafe(EUS)	Unsafe(US)	Moderately Unsafe(MUS)	Safe(S)	Extremely Safe(ES)

Safety Performance level of construction projects has been assessed based on percentage safety performance Index (%SPI) using the criteria mentioned in Table 1.

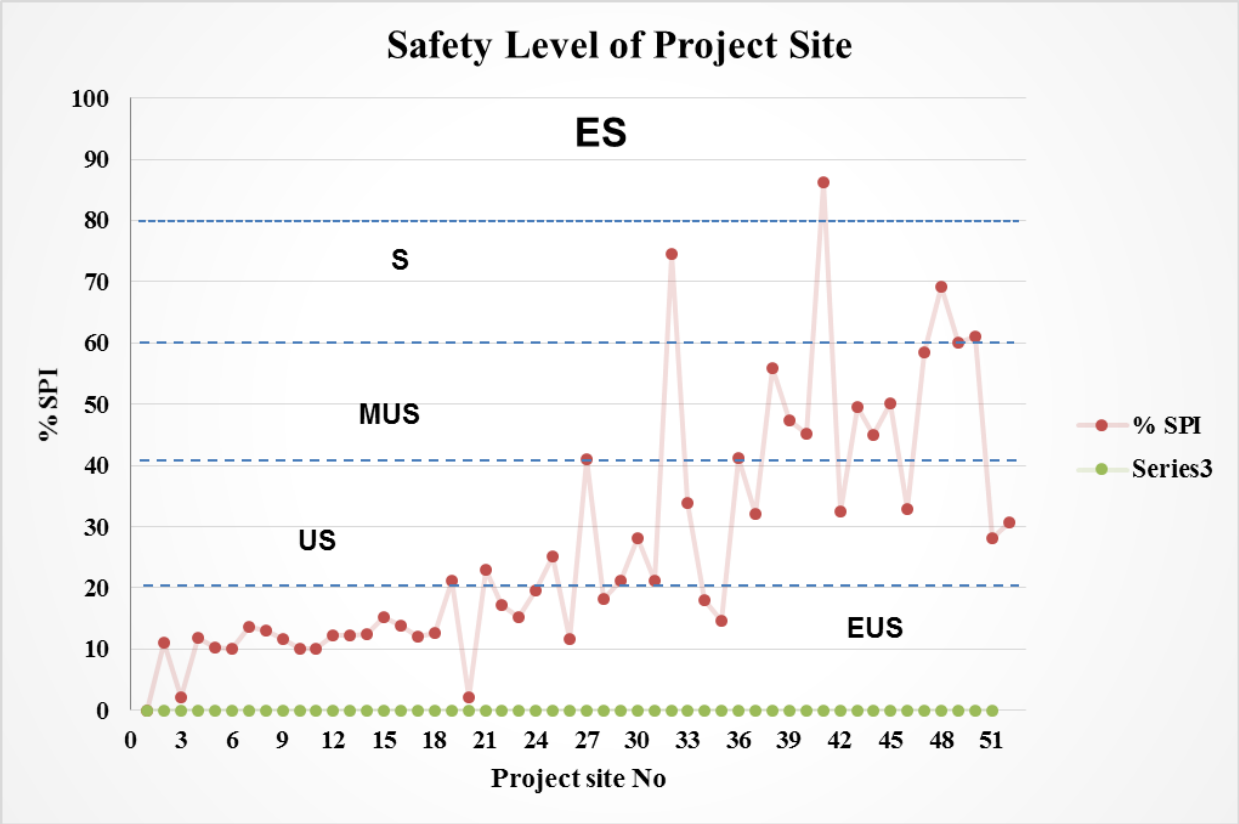
7. RESULTS AND FINDINGS

The essential information gathered from the first piece of the survey was broken down from the view point of owners, developers, contractors and project managers.

Table 2: Site Safety Performance Summary

PROJECT SITE NO	SNPI	SPI	%SPI	SAFETY LEVEL
1	0.88848	0.11152	11.152	EUS
2	0.97865	0.02135	2.135	EUS
3	0.88091	0.11909	11.909	EUS
4	0.89697	0.10303	10.303	EUS
5	0.89848	0.10152	10.152	EUS
6	0.86333	0.13667	13.667	EUS
7	0.86879	0.13121	13.121	EUS
8	0.88364	0.11636	11.636	EUS
9	0.8997	0.1003	10.03	EUS
10	0.89879	0.10121	10.121	EUS

11	0.87727	0.12273	12.273	EUS
12	0.87788	0.12212	12.212	EUS
13	0.87485	0.12515	12.515	EUS
14	0.84818	0.15182	15.182	EUS
15	0.86061	0.13939	13.939	EUS
16	0.87939	0.12061	12.061	EUS
17	0.87273	0.12727	12.727	EUS
18	0.78848	0.21152	21.152	US
19	0.97865	0.02135	2.135	EUS
20	0.77091	0.22909	22.909	US
21	0.82697	0.17303	17.303	EUS
22	0.84848	0.15152	15.152	EUS
23	0.80364	0.19636	19.636	EUS
24	0.74879	0.25121	25.121	US
25	0.88364	0.11636	11.636	EUS
26	0.58984	0.41016	41.016	MUS
27	0.81879	0.18121	18.121	EUS
28	0.78727	0.21273	21.273	US
29	0.71788	0.28212	28.212	US
30	0.7875	0.2125	21.25	US
31	0.2538	0.7462	74.62	S
32	0.66061	0.33939	33.939	S
33	0.81939	0.18061	18.061	EUS
34	0.85273	0.14727	14.727	EUS
35	0.58848	0.41152	41.152	MUS
36	0.67865	0.32135	32.135	US
37	0.44091	0.55909	55.909	MUS
38	0.52697	0.47303	47.303	MUS
39	0.54848	0.45152	45.152	MUS
40	0.1367	0.8633	86.33	ES
41	0.674879	0.325121	32.5121	US
42	0.50364	0.49636	49.636	MUS
43	0.54984	0.45016	45.016	MUS
44	0.49898	0.50102	50.102	MUS
45	0.67188	0.32812	32.812	US
46	0.41458	0.58542	58.542	MUS
47	0.3078	0.6922	69.22	S
48	0.3989	0.6011	60.11	S
49	0.3889	0.6111	61.11	S
50	0.71939	0.28061	28.061	US
51	0.69273	0.30727	30.727	US



(Where EUS=Extremely Unsafe, US= unsafe, MUS=Moderately Unsafe, S=Safe, ES=Extremely Safe)

Fig.1 SAFETY LEVEL OF PROJECT SITES

Fig. 1 indicates the of safety performance level of total 51 sites where sites are running between extremely unsafe to moderately unsafe level and others between safe to extremely safe level. Summary of performance level of project sites is mentioned in table 3 given below.

Table 3: Summary of Performance Level

Performance Level	No of Sites
Extremely Unsafe(EUS)	25
Unsafe(US)	11
Moderately Unsafe(MUS)	9
Safe(S)	5
Extremely Safe(ES)	1

Result indicates that most of the projects lie in the range of extremely unsafe to moderately unsafe and the rest are in the safer range (Table 2). This shows that overall level of the industry as regard to project site safety needs drastic improvement. Safety seems to be on the less priority on the agenda even during the execution phase that is not a healthy trend for the industry.

Results also indicate that safety performance of construction projects depends upon the various category of factors as mentioned above. Majority of safety non-performance issues belongs to self-protection and access to height category.

8. CONCLUSION

From the questionnaire survey in various cities from Gujarat following results are concluded about safety performance levels of construction projects:

1. The results from the questionnaire survey highlighted very poor and bad safety performance level of construction projects in Gujarat. There was no detailed record was available for the size and number of accidents that shows the clear statistic for accidents and injuries.

2. The main factors belong from self- protection and access to height category playing most important role in safety performance level of construction projects. On the existing safety procedures, regulations, policies, and accidents prevention methods related to the construction projects; there was a consensus among the respondents that implementation of safety regulation helps in reducing accidents. Construction professionals should play more active roles in sustaining construction safety and in improving safety culture for construction workers.

3. From the safety performance index most of the construction projects are running in extremely unsafe to moderately unsafe level the industry need to improve the performance level by applying safety standards, creating safety culture on project site, mechanization and industrialization and enhancing the working condition through necessary provision of safety equipment's and regulations.

4. Also the government regulatory authorities need to enhance the old rules and regulations with the strong terms of punishments and compensation for those who make safety violation. Also the applications and provisions provided at project level must be follow up for evaluating the performance level through periodic inspections and visits by government officials of safety.

6. REFERENCES

1. Charehzehi, Aref, and Ahankoob, Alireza. "Enhancement of Safety Performance at Construction Site", International Journal of Advances in Engineering & Technology, ISSN: 2231-1963, Volume 5, Issue 1, **November 2012**, 303-312.

2. Choudhry, Rafiq M, and Fang, Dongping, and Ahmed, Syed M. "Safety Management in Construction: Best Practices in Hong Kong", Journal of Professional Issues in Engineering Education and Practice", ISSN: 1052-3928, Volume 134, Issue 1, **January 2008**, 20-32.

3. De-Chun, Ning, and Jian-ping, Wang, and Guo-dong, Ni. "Analysis of Factors Affecting Safety Management in Construction Projects", International Conference on Management and Service Science (MASS) 2010, ISBN: 978-1-4244-5325-2, **2010**, 1-5.

4. El-Mashaleh, Mohammad S, and Al-Smadi, Bashar M, and Hyari, Khalied H, and Rababeh, Shaher M. "Safety Management in the Jordanian Construction Industry", Jordan Journal of Civil Engineering, ISSN: 1993-0461, Volume 4, No. 1, **2010**, 47-54.

5. Huang, X, and Hinze, J. (2006). "Owner's role in construction safety." Journal of Construction Engineering and Management, 132 (2), 164-173.

6. K. Mauleeswaran. "Evaluation of safety performance level of construction firms in and around Erode zone", InternationalJournalofInnovativeResearchin Science,Engineeringand Technology (IJIRSET), ISSN: 2319-8753, Volume-3, Special Issue,**2014**, 1590-1596.

7. Laryea, Samuel, and Mensah, Sarfo. "Health and safety on construction sites in Ghana", Ghana. In: The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, ISBN: 978-1-84219-619-9, **2010**.

8. Patel P. N, Bhatt R. B., Pitroda J. P, " Identification of Factor Affecting Safety Performance on Construction Projects in Gujarat", International Conference on: "Engineering: Issues, opportunities and

Challenges for Development, ISBN: 978-81-929339-3-1, April 2016

9. Sawacha, Edwin, and Naoum, Shamil, and Fong, Daniel. "Factors affecting safety performance on construction sites", International Journal of Project Management, ISSN: 0263-7863, Volume 17, No. 5, **1999**, 309-315.

10. Sincich, T.,Levine, D.M., and Stephan, D. "Practical statistics by example using Microsoft Excel and Minitab",2002, 2nd Ed, Prentice Hall, Upper Saddle River,NJ.

11. Suazo, G.A., and JAselskies E.J. "Comparision of construction safety codes in Unaited States and Honduras", Journal of Construction Engineering and Management,119(3),560-572

12. Sunindijo, Riza Yosia, and Zou, Patrick X. W. "Conceptualizing Safety Management in Construction Projects", Journal of Construction Engineering and Management, ISSN: 0733-9364, Volume 139, No. 9, **September 2013**, 1144-1153.