

Developing Model of Construction Safety

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Abstract- *The construction industry experiences higher rate of occupational injuries, illness as compared to other industries. In construction industry workers are exposed to hazardous conditions, this is difficult to quantify because work location for often change. Poor safety on site affects workers in physical and psychological way that impact on project by increasing direct and indirect cost. An emphasis on construction safety has increased for aspect of safety performance and efforts are required to not only monitor but also seek to improve safety performance. Construction companies implementing safety, health and environmental management system to reduce injuries, eliminate illness and to provide a safe work environment on site. Some companies consider conventional model of construction safety for enhancing safety performance and selected one that is regarded as most promising or cost effective. To overcome limitations of conventional models and BIM, there is need of developing model to enhance and improve the measures in culture of construction safety in India. The Safety rating system provides an opportunity to rate worker based on the safety performance and the degree of implementation of safety and health elements on construction site. This rating system can be used as an effective tool to develop and plan construction safety and health programs and evaluate the potential safety performance by workers on construction projects. In this study 10 construction sites were to be taken.*

Keywords- Building Information Model (BIM), Safety Performance Evaluation, Rating, Safety Culture

I. INTRODUCTION

Globally, the construction industry experiences one of the highest rates of occupational injuries, illnesses, and fatalities when compared with other industries. The global importance of the construction industry in producing facilities that support various economic activities and contribute to the delivery of social and environmental needs of a nation makes construction safety a crucial subject of concern. In the construction industry workers are exposed to hazards that are difficult to quantify because work locations for any group of workers often change and each work site evolves as construction proceeds, changing the hazards workers face on a regular basis. Poor safety for construction sites affects

workers and their relatives in physical and psychological ways which impact on the project financially by increasing direct and indirect costs. There are many different safety programs, techniques, and initiatives that can be implemented to enhance safety performance. Many companies consider means of enhancing safety performance and select most promising or cost effective. Each practice that is implemented will result in a cost, which involves initial development, tailoring the strategy to company operations, and ongoing implementation. Details of program implementation must be drafted, supervisors and workers must be trained and informed about the new practices, and the practices must then be monitored to evaluate their success. Hazard recognition and the accurate perception of safety risk are fundamental to the success of any safety program. When hazards unrecognized, the unexpected injuries dramatically increase. For improve hazard identification, employers require adopting training programs. The rating system provides an opportunity to rate worker based on safety performance and degree of implementation of safety and health elements on construction site. This rating system can be used as an effective tool to develop and plan construction safety and health programs and evaluate the potential safety performance of worker on construction projects.

II. LITERATURE REVIEW

Ibukun G. Awolus, A.M.ASCE, and Eric D. Marks, Ph.D., P.E., S.M.ASCE [1], Hazard recognition and the accurate perception of safety risk are fundamental to the success of any safety program. When hazards remain unrecognized, or the associated safety risk is underestimated, injuries dramatically increase. To improve hazard recognition and the accurate perception of safety risk, employers adopt a wide variety of training programs. In this paper, the prevalent use of ineffective and un-engaging training methods has significantly impeded training efforts in construction. The purpose of this research was to assess the impact of safety training on two objective training outcomes: hazard recognition performance and safety risk perception. The research objectives were accomplished by gathering empirical data from 51 active projects in the United States. The results of the study revealed that (1) compared to low-engagement training, high-engagement training is associated with higher

levels of hazard recognition and safety risk perception; and (2) the effect of training on safety risk perception is mediated by hazard recognition performance. Therefore, workers representing projects that offered high-engagement training were able to identify a larger proportion of hazards, and consequently perceived that safety risk was relatively higher. The findings of this study will be useful to practicing professionals seeking to improve training delivery, hazard recognition performance, and the perception of safety risk within construction.

Luis Fernando Alarcon, Diego Acuna, Sven Diethelm, Eugenio Pellicer[2], The authors selected a sample of 1180 construction firms and 221 individual practices applied in these companies to analyze their effectiveness reducing injury rates over four years in Chile. Different methods were used to study this including: visual analyses of graphical information, statistical analyses and classification techniques. Results showed that practices related to safety incentives and rewards are the most effective from the accident rate viewpoint. The higher the percentage of prevention practices implemented in a strategy, the lower the accident rate. The Safety database included data of construction companies and prevention practices carried out every year. The next step was to identify the prevention practices under-taken each year by each company. There were a total of 221 different prevention practices; the next step was to group prevention practices into categories to simplify the analysis. The classification of activities performed by the Safety Mutual, the research team decided to classify the 221 practices into seven categories of practices, as follows: 1. Accidents & Incidents Investigation: activities related to the capture of information of accidents and incidents. 2 Safety Planning & Resources: activities carried out by safety staff (such as the preparation of safety plans) as well as activities related with safety equipment that workers should use. 3 Management Commitment: activities that demonstrate the willingness and commitment to safety from management, which otherwise would not be carried out. 4 Workers' Safety Training: activities such as courses, workshops, seminars, and all kind of safety training for workers. 5 Management Safety Training: similar to the previous group, but focused on the company management. 6 Audits & Certifications: regular activities performed by the Safety Mutual. 7 Safety Incentives & Rewards: all kinds of recognition for good safety records. Companies that do not implement any practice in this category have an accident rate 51% higher than companies that do implement this category.

III. MEANING OF CONSTRUCTION SAFETY CULTURE MODEL

Safety culture is a part of organizational culture is way we do things around here. Studies are show that workplace are a result of a breakdown in an organization's policies and procedures that are established to deal with safety. A good safety culture can be promoted by senior management commitment to safety, realistic practices for handling hazards, continuous organizational learning, and care and concern for hazards shared across the workforce. Safety culture is defined as those aspects of the organizational culture that will impact on attitudes and behavior related to increasing or decreasing risk. Safety culture is a sub facet of organizational culture that affects workers' attitudes and behavior in relation to an organization's on going safety performance. Improving site safety is a top priority for construction companies throughout the world.

IV. PROBLEM FACING IN CONVENTIONAL CONSTRUCTION SAFETY MODELS

Construction industry employs skilled and unskilled workers subject to construction site accidents and health risks. A proper coordination between contractors, clients, and workforce is needed for safe work conditions which are very much lacking in Indian construction companies. Today various worker safety laws are available but the number of accidents taking place at construction sites. Management commitment towards health and safety of the workers is also false. The Indian construction worker force is 7.5% of the total world worker force and it contributes to 16.4% of global occupational accidents. In the construction industry the possibility of a fatality is five times more likely than in a manufacturing industry, whereas the risk of a major injury is two and a half times higher. India has the world's highest accident rate among construction workers, according to a recent study by the International Labour Organization (ILO) that cited one survey by a local aid group showing that 165 out of every 1,000 workers are injured on the job. Lack of communication among the various departments involved and lack of proper inspections are the major reasons for accidents occurring at a construction sites.

Limitation is associated with study inference. The injury, accident report used for the study is tried to keep clean to make it strongest statement by respective site authority. They were just trying to hide the accident information that was happen on site. While survey requested information about safety activities implemented by owner, designer, contractor and subcontractor, in some cases only 5 firms completed entire survey. For this cases reliability of information provided depends on respondent.

At the time of giving penalty to any worker on small scale site, they are tried to quit the work because of giving less amount of payment. Because on small scale site there is limited no. of Thekedar (Subcontractor), so they are trying to keep burden on contractor for work. But this is not happens on big scale site, there is lots of Subcontractor to do this work as per contractors directions.

V. DEVELOPING A MODEL FOR CONSTRUCTION SAFETY CULTURE

A. Model System

Data collection from site: Data collection aims to gather and measure information on variables of interest, and capture quality evidence that translates to rich data analysis. Use Inspection checklists to cover various categories and methodologies. The checklist must covers site condition, labours number, equipment's use on site, accident report, safety use on site, site detail of financial budget, employer and employee's detail.

Safety Planning: After gathering all the information of construction site, there is required is planning for safety program arranged on site. Planning of safety should be based on accident happens on site, cause of accident, requirement of safety. In the planning for safety it is required to take psychology of worker about understanding the safety program.

Training of Employees: Construction jobsites are among the most dangerous workplaces, with fatalities and recurring accidents still plaguing the industry. These occur for various reasons; however, one underlying cause relates to deficiencies in the education and training of construction project personnel. Efficient and effective safety training programs have the potential to improve safety performance by preventing accident occurrence. Safety training also improves behavioral attitudes and makes accidents more predictable. Currently, at the industry level, typical safety training programs are delivered through on-site workshops. Some of these include mentoring programs and use buddy systems to help orient new employees. However, a large proportion of these have proven ineffective in sufficiently preparing workers and graduates for the work site. On the other hand, at the tertiary institution level, construction curricula vary in their approaches to safety education; with some programs including safety topics in their curricula while others do not. Furthermore, the majority of the programs that do consider site safety matters utilize teaching strategies that have been criticized for being passive, boring, and not sufficiently motivating. In attempts to improve tertiary education, mobile app technologies have been applied and proved beneficial in various disciplines. Through the use of

mobile devices, the proposed system creates immersive, accessible, and captivating learning environments that afford learners an experiential opportunity to acquire safety knowledge and improve their hazard-identification abilities. Mobile app is adopted as a cognitive learning platform allowing learners to examine virtual site environments, identify hazards, and perceive the direct consequences of their actions, without detrimental real-life consequences. In these mobile Worker can understand the safe way to handle any activities without any accident. In this application worker can learn a safety equipment, its safe way for handling, what to do? And what can be avoided? This can be helpful for worker to understand the safety.

B. Evaluation and Analysis of safety performance

Performance Evaluation: Safety management is an integral part of project management, and safety performance is possible if only there is an effective safety management. A proper performance evaluation is also found to be crucial for effective safety management on construction sites. For this study we have select construction 10 site. On every site by work study method with the help of safety performance checklist, every worker performance can be evaluated with help of supervisor. In this checklist worker can be examine for their performance on safety. Site supervisor can daily check worker action with regarding safety and categories each worker into 4 groups.

Rating: Rating system provide an opportunity to rate the workers performance on importance given to safety and health and degree of implementation of safety and health element on construction site. With help of above evaluation system, worker can be categories into 4 groups of rating. For this rating following criteria can be used-

Rating 1-

Safety working is of good quality and operating normally, The various working like personnel, environmental, management are well coordinated, The overall safety situation is in ideal condition and there are fewer defects, Safety training is realized with information technology in scientific and precision-oriented way, Performance of overall can reach, efficiency improved, quality of work have greatly improved, and resource consumption reduced.

Rating 2-

Safety working is of comparatively good quality and stable operation, The various working like personnel, environmental, management are comparatively coordinated, The overall

safety situation is in good condition. Sometimes it is not stable and with some deficiencies, Some part of system realized information, All work is in good relation, Theory and practical operations are comparatively well organized and controlled.

Rating 3-

The quality of safety work is acceptable, The various work of personnel, environmental, management is not fully coordinated, The overall safety situation is acceptable; there are some defects and potential risks of accidents, Work realized to provide information to some extent, The goal is achieved generally, cost is high for work.

Rating 4-

The quality of work is poor and operation is not normal, Various work of personnel, environmental, management is not coordinated, Overall safety situation is poor; there are many defects and potential risk of accident, Unscientific, there is no corresponding information application, The goal cannot be achieved, safety efficiency is low.

In this evaluation some other point can be examine- Wastage of material, listening of directions, Alcohol and drugs consumption on site, Sense of responsibility, Safety awareness, Physical and mental quality, Ability of emergency response, Effectiveness of daily safety work, Illegal action on site.

Analysis of Safety Performance: The information about Safety performance check by the supervisor can be then analyses based on the above rating criteria workers can be categories in the four rating system. The safety behavior, safety knowledge, safety action and other safety points of worker can be helpful for categorization. In 10 site survey it was saw that out of 200 workers only 32 workers can up to the mark for Rating 1, 88 workers in the Rating 2, 59 workers in the Rating 3 and remaining 21 workers are in Rating 4.

Incentives (Reward) or Penalties: Based on the performance of safety, worker can applies for the Reward or Penalties. In this section of awarding, the rewards and penalties amount can be depend on Management of respective site. They can be decide how much of reward or penalties can be applied on worker.

Future Safety planning: Depends upon the mention safety performance evaluation, there is also required to examine the various factors which is helpful for the future safety planning. In this various mark able factors which can be note down

during process of performance evaluation. These factors are as follows-

- Safety rules and regulation
- Occupational health and safety program
- Safety investment
- Emergency preparedness
- Safety inspection
- Safety meeting
- Safety plan and record
- Safety education and training
- Incident investigation and analysis
- Safety knowledge
- Safety attitude
- Safety involvement
- Safety qualification
- Machinery and equipment maintenance
- Personnel protective equipment
- Safety operation procedure
- Hazardous substance control

These factors can be examined during the evaluation. By this we can easily detect which factor was not properly implemented during entire work. In the next session of training exercise these factors can be detailed explain to employee. Hence this can be easily resolve and helpful for the future safety planning.

VI. RESULT

This study applies the concept of construction safety culture for the worker safety and health with developing a safety performance rating system. This rating system provides an opportunity to rate the workers performance on importance given for safety and health and degree of implementation of safety and health elements on site.

In this paper, the development of rating system was described. The rating system was developed with the help of work study method. In this we have taken 10 construction sites for work. All projects were constructed (some in progress) within previous year, throughout Pune and Pimpri-Chinchwad, Maharashtra, India. The cost of projects was from 20 Lakhs to 200 Lakhs Rupees. The data received for 10 projects included number of workers for entire project duration. It should be noted that from 10 projects, 8 projects were in progress at the time of study. Remaining 2 projects were beginning from the study. Out of these 7 projects are 80% completed and remaining 3 are almost done. The data provided on the entire 10 site included total number of injuries, accident, incidents that were happened on site and the total number of workers on sites.

By the worker performance evaluation system, workers were categorized in 4 rating system.

Table -1: Safety Performance Rating

Site	Number of Workers			
	Rating 1	Rating 2	Rating 3	Rating 4
1	3	9	6	2
2	4	7	6	3
3	2	10	7	1
4	2	8	8	2
5	4	9	6	1
6	2	11	5	2
7	2	10	4	4
8	4	8	6	2
9	5	7	5	3
10	4	9	6	1

After application safety culture model on 10 construction site, the accident rate is can be reduced some extent. It means there is negative correlation between accident rate and the safety performance. But for site it could not change because of worker ignorance in the safety behavior as well as management interference in the incentive scheme.

Workers are the major contributors and cause of accidents on construction sites. workers are either been paid on a daily basis or finish and go method this creates an environment in which these workers hastily and impatiently carryout their work thereby ignoring safe working practices and creating grounds in which accidents are likely to occur. Firms should either stop the finish and go method of payment or constantly supervise their workers if they should adopt this method. By the study it was saw that there is most common reason for accident on site. This can be solved by proper training on that activities in the future planning. These causes are as follows,

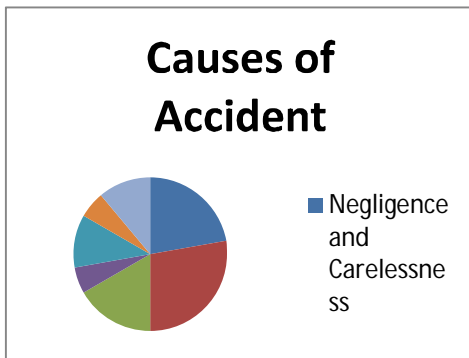


Figure 1 – Analysis of causes of accidents in the study

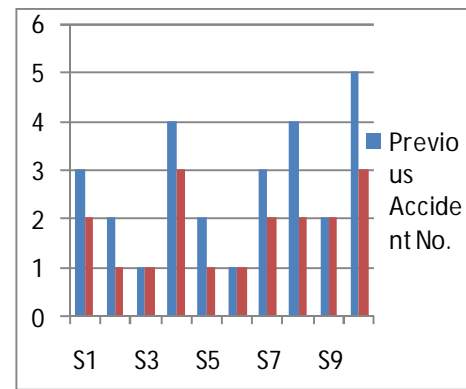


Figure 2- Analysis of impact of safety performance

Rather than having the employees play main role in safety, all parties should be involved in project safety effort to have safety culture result.

VI. CONCLUSION

Generally, construction firms must complete projects on schedule and on budget. However the poor safety performance of the construction industry continues to give international cause for concern. Safety management systems are introduced into the construction industry as a formal system to manage site safety. A proper performance evaluation of safety management is also found to be crucial for effective safety management.

The results of this study indicate that the worker construction safety performance is a very complex problem and the factors to be considered are more comprehensive. Construction firms should be continuously modified and amended during practical application of safety management. The education and training on safety should be strengthened. And the rules and regulations of safety management should also be further perfected. If workers can routinely focus on safety management, construction firms with a successful safety management system and a good safety performance can enjoy sustainable competitive advantages. Although the application of the model proposed in this study is specific to construction safety performance of workers, it can be modified so that it could be used in other safety management system. After the evaluation results of safety performance, safety conduct code, safety culture and their averages, the enterprise could identify the areas in which the construction of safety culture is not sufficient. With deficiencies showed by analysis, the enterprise is able to decide the direction of construction and build safety culture on purpose, so the enterprise could improve safety culture much more than ever with the same resource in order to guarantee the production system running safely.

REFERENCES

- [1] Rafiq M. Choudhry, Dongping Fang and Sherif Mohamed, “Developing a Model of Construction Safety Culture”, *J. Manage. Eng.*, pp. 23:207-212, 2007
- [2] Ibukun G. Awolus, A.M.ASCE, and Eric D. Marks, Ph.D., P.E., S.M.ASCE, “Safety Activity Analysis Framework to Evaluate Safety Performance in Construction”, *J. Constr. Eng. Manage.*, pp. 05016022, 2016
- [3] Luis Fernando Alarcon, Diego Acuna, Sven Diethelm, Eugenio Pellicer, “Strategies for improving safety performance in construction firms”, L.F. Alarcon et al. / *Accident Analysis and Prevention* 94, pp. 107–118, 2016
- [4] Xianguo Wu, Qian Liu, Limao Zhang, Mirosław J. Skibniewski, Yanhong Wang, “Prospective safety performance evaluation on construction sites”, X. Wu et al. / *Accident Analysis and Prevention* 78, pp. 58–72, 2015
- [5] Yang Chun-zhou, Liu Hua-yu, Zhan Xi-chen, Zheng Hai-ping, “Construction of Ship Safety Management Performance Evaluation System”, *IEEE*, pp. 978-1-4244-5326-9/10, 2010
- [6] Cheng-Hua LI, Hui-Min LI, “Developing a Model to Evaluate the Safety Management Performance of Construction Projects”, *IEEE*, pp. 978-1-4244-4639-1/09, 2009
- [7] Dr. AnoopSattineni and Taylor Schmidt, “Implementation of mobile devices on jobsites in the construction industry”, AnoopSattineni and Taylor Schmidt / *Procedia Engineering*, pp. 488-495, 2015
- [8] MostafaNamian, S.M.ASCE; Alex Albert, A.M.ASCE; Carlos M. Zuluaga, S.M.ASCE; and Michael Behm, “Role of Safety Training: Impact on Hazard Recognition and Safety Risk Perception”, *J. Constr. Eng. Manage.*, pp. 04016073-1-10, 2016