OPERATIONAL SAFETY OF CONSTRUCTION PROJECTS IN PAKISTAN: AN EXPLORATORY EMPIRICAL STUDY USING FIELD DATA

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This thesis is dedicated to my parents who always made sacrifices to ensure all good for me and my siblings Aisha and Dawood for being an unending source of love and encouragement.

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ABSTRACT

Even with enhanced knowledge and awareness, construction industry continues to rank among the most hazardous occupations in the world. Construction industry incurs thousands of fatalities and injuries to construction workers worldwide each year. Construction safety remains a matter of significant concern for different stake holders both in developed and developing countries. Pakistan like many other developing countries has failed to respond to latest technological improvements, thus continue to face burden of fatalities and injuries resulting from unsafe practices at construction sites.

A number of studies in the past have evaluated the safety practices of construction projects with main focus on management aspects of construction safety such as firm safety policy, management commitment and skills, safety audits, integration of safety resources in time and cost schedules, improvisation of safety plan using worker feedback and experience, reward and punishment system, hazard analyses and reporting mechanism of accidents and near misses. However there are limited studies that have explored the actual on-site safety conditions of different construction projects and studied the use of personal protective equipment, excavation safety, ladder safety, lift safety and scaffold safety etc. Also there is no study at national level that has explored the relationship between overall onsite safety condition of a construction project and different project features and managerial aspects of a construction project's safety. Using detailed literature review, managerial and operational aspects of construction projects safety were identified. Using expert opinion ranking of projects managerial and operational

factors was developed. Data from 45 different construction projects located in 3 different cities were collected and collated to estimate safety performance index for each project. It was revealed that large projects and projects being executed by foreign firms/ semi government organizations have better safety performance. Lastly an ordered probit model was developed to explore relationship between managerial and operational characteristics of the construction projects.

Analyses reveled that projects being executed by firms having safety policy as part of bid evaluation, proper site visits by project management team, regular tool box meeting, availing services of a qualified safety supervisor, large contract size and higher percentage of skilled labor were having better overall on-site safety. The results of the present study shall enable national construction agencies to appropriately formulate strategies to enhance construction safety in Pakistan.

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LIST OF ABBREVIATIONS

RIR	=	Recordable Injury Rate
PPE	=	Personal Protective Equipment
SMS	=	Safety Management System
SPE	=	Safety Performance Evaluation
SCE	=	Safety Culture Evaluation
OSHA	=	Occupational Safety and Health Association
ARCTM	=	Accident Root Cause Trace Method
OHS	=	Occupational Health and Safety
OHSAS	=	Occupational Health and Safety Assessment Specifications
3P+I	=	Policy, Process, Personal and Incentive Factors

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

Construction industry is considered as one of the most important contributor in the economy of a country. Construction industry is also regarded as one of the most hazardous and unsafe industry to work in (Perttula et al., 2006; Pinto et al., 2011). This is due to the unique and complex nature of construction activities. Moreover, construction has both direct and indirect impact on the human population, in the form of end-users and workers who are physically involved in the construction activities. Construction industry employs around 7% of human force (Sunindijo and Zuo, 2012; Zahoor et al., 2015) among all the industries. While considering the significance of this industry, it is not un-disclosed that construction industry is also unfortunate holding the poorest and alarming records in health and safety of workers (Mohammed, S, 2002; Huang and Hinze, 2006; Haadir and Panuwatwanich, 2011; Zahoor et al., 2015). It is evident that despite of intense research carried out on safety in construction, it is yet in the destructive form of performance. High fatality and injury rates on construction sites are faced all over the world. Even the developed countries like USA, UK, Australia, Canada, Singapore and Sweden, the fatality rates and safety performances are not satisfactory.

Construction activities are considered unsafe due to their complexity, uniqueness, interconnectivity and divergent site conditions from site to site (Farooqui et al., 2008). These reasons make fatalities, injuries and accidents inevitable in construction workplaces. Many injuries and fatalities occur at site during the course of constructing a project. Some of the reasons for fatalities and injuries as described in various studies are misjudgment of job-hazards, unsafe worker behaviors (Mohammed, 2002, Ahmed et al., 2000), unavailability of personal protective equipment (PPE) (Haadir et al., 2011),lack of safety knowledge and exposure to hazardous sources (Huang and Hinze, 2003, Tam et al., 2004, Chi et al., 2005, Glanzer et al., 2005, Haslam et al., 2005, Hinze et al., 2005, Teo et al., 2005, Choudhary and Fang ,2008, Saurin and Guimaraes, 2008, Farooqui et al., 2008, Garrett and Teizer, 2009, Chi et al., 2009, Cheng et al., 2010, Ismail et al., 2012, Leung et al., 2012, Raheem and Hinze, 2013) . While in view of the construction complexity the advanced technology use on sites and unavailability of skilled workers are some of the major reasons of unsafe work environment (Farooqui et al., 2008).

Various strategies are worked out that address safety of workplace. A well-developed safety management system is essential to control the safety at construction sites. This system includes management, technical and regulatory practices that ultimately influence the construction safety. The safety management systems may differ from country to country on the basis of the set of best safety practices of particular region or the country (Ismail et al., 2011). A thorough literature review has been carried out to gather an optimum set of best safety practices that constitute an optimum and near best safety management system. Lin et al. (2008) suggested that along with the development of safety management frameworks, safety performance evaluation are equally important to examine the effectiveness and success of safety research and implementation efforts so far.

Construction industry in Pakistan is yet in sprouting stage of construction health and safety implementation zone. It stands at second highest rank in causing fatalities on job among all industries. With the sound base of safety management frameworks and recommendations, now is the time to evaluate the current performance of contractors/sub-contractors in achieving the objectives of most of the studies conducted nation-wide. Farooqui et al. (2008) conducted an investigation on safety performance at construction sites in Pakistan and established an evaluation system related to accidents occurred on those sites.

There has been very few efforts done so far to explore the actual on-site scenario that is going on and the safety evaluation on the basis of safety culture and climate of the firms. This study is intended to evaluate different construction projects' safety performance with actual on-site observations. On the basis of field safety data, projects and firms will be ranked across a set of key safety factors. It will also investigate the trend of safety performance in relationship with the major project features. The results will portray the current safety culture of Pakistan construction industry and the reasons behind it. It will help regulatory authorities to identify the problem areas and set-up procedures for improvement.

1.2 PROBLEM STATEMENT

Construction industry in Pakistan is standing far behind in the battle of providing safety on construction sites to the workforce and the project overall. Major reasons behind safety non-performance is the absence of safety management systems and on-site safety performance activities. Many studies have been conducted so far that address the safety management framework but very less efforts have been made to analyze the phenomenon of actual safety performance on sites. Even a set of safety management practices fail to provide proper on-site safety due to many factors intervening in the observance of operational safety practices. The present research intends to explore the relationship between a safety culture, project characteristics and on site safety performance category. However, the technical distinction between concessions and operating concessions may be of great significance in respect of rules on public finances and tendering.

1.3 RESEARCH OBJECTIVES

The set of objectives set forth for this study are:

- To review state of art safety practices at firm level and sites.
- To analyze existing safety situation of construction projects in Pakistan construction industry.
- To rank projects on basis of safety performance.
- To explore the relationship between project/ firm characteristics with its safety performance on sites.

1.4 OVERVIEW OF STUDY METHODOLOG

In order to achieve the objectives of the research, a detailed methodology (Figure 1) was worked out which has following research steps that were undertaken; First, Literature review of the previous relevant research works at national/international level. Then, Identification of major safety management and on-site operational factors. After that, Ranking of the management and operational factors using expert opinion. Then, Collection of firm and on-site data based on management and operational factors respectively through interviews and physical site observations. Next step is the comparison of safety performance with the various project features. Then, to explore the relationship between on-site safety performance and management aspects and project characteristics. Second last step is the analysis and discussions. Lastly, conclusion and recommendations.

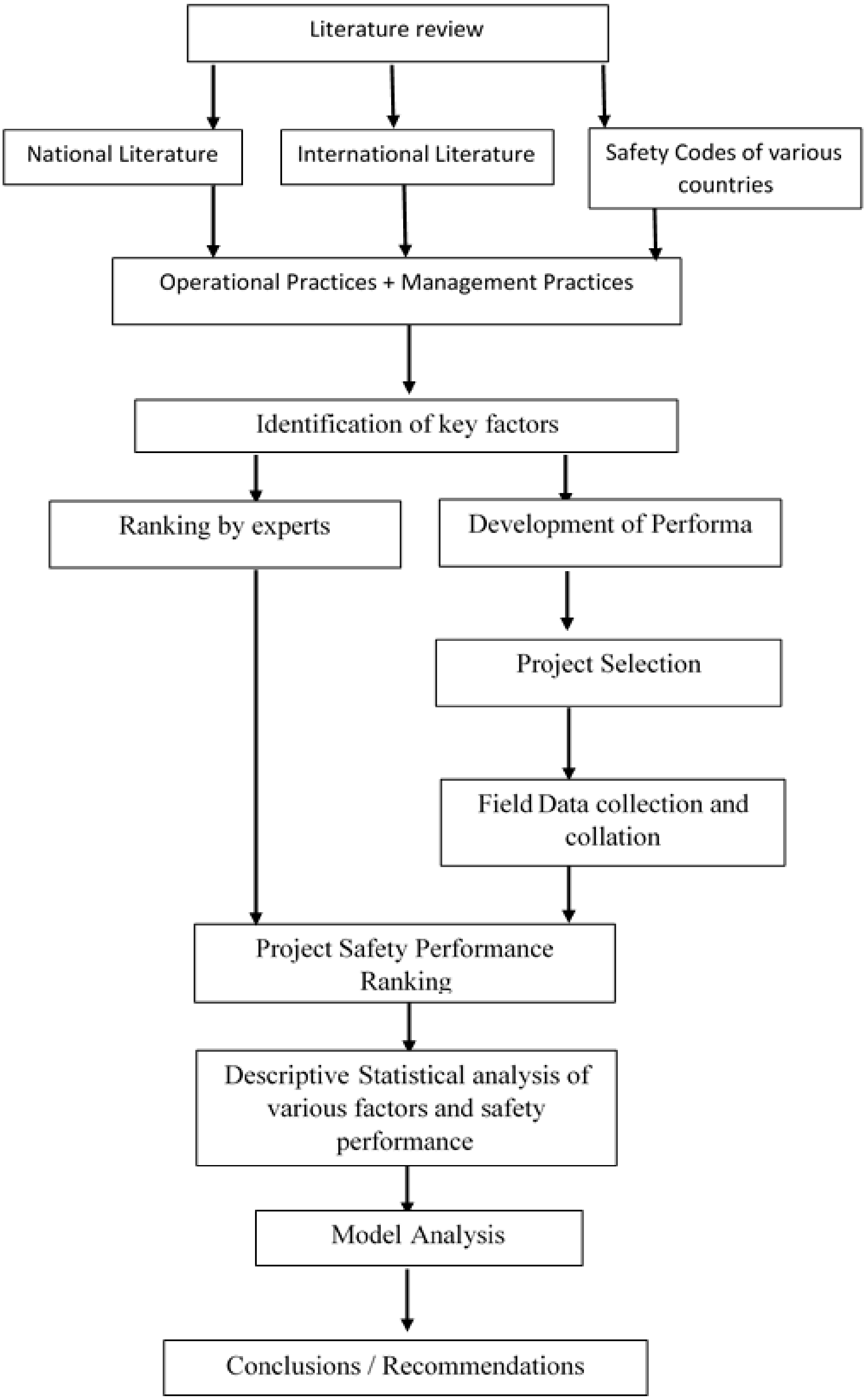

Figure 1: Overview of Study Methodology

1.5 THESIS ORGANIZATION

This research is structured into six chapters. The need for field data investigation of safety on projects and study objectives are discussed in Chapter 1. Chapter 2 provides a literature review on safety management system and performance evaluation. In Chapter 3 the safety management system factors and project features are discusses. The current state of art safety practices scenario trends are discussed in chapter 3.Chapter 4 covers the comparisons of project features and safety performance. It also covers the project safety rankings. Chapter 5 describes the relationship model. Finally, the research summary, conclusions, and recommendations are explained in Chapter 6.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter represents the summary of various past studies carried out on the construction work place (site) safety. Major safety factors at organizational level are discussed in this chapter that are used to evaluate the safety performance. The studies represent the evolution of construction safety and its evaluation techniques in the past decade. In earlier years construction safety was measured in terms of the lagging indicators like incident rate and compensation costs incurred. But, in recent studies emphasis has been laid on considering the leading indicators of a construction safety. This chapter also discusses the diverse kinds of methodologies and data that have been used to evaluate the safety performance of firms.

The chapter initially covers the studies of international researchers on the construction safety evaluation on the basis of both reactive and pro-active strategy. Studies have been conducted that describe the major reasons of safety failures in different construction industries. Lack of knowledge of workers, avoidance to observe PPE rules and inability to identify hazards were the major reasons at the workers end. Whereas, lack of interest by the management and prioritizing production over safety are from the authorities end. To remove these obstacles studies have worked out the management and operational practices to create a sound safety climate on the sites. Most common recommendations of the studies have laid importance towards the prospective evaluation of construction safety.

Following are the national studies that reveal that the construction safety in Pakistan has yet to be enlightened in terms of its evaluation, enforcement and data collation. Major problem discussed was the absence of a regulatory authority and inspection teams that would enforce safety as a mandatory part of execution. Further, there is a lack of accident record method and accident data that would clarify the actual picture of safety on construction sites of Pakistan. A summary has been presented of the national studies with major recommendations.

After the management practices gathering from the research studies, the operational safety practices were gathered from the research and safety codes and regulations of different countries like USA (OSHA Standards), UK, Singapore, Australia, Ireland, Malaysia, UAE and Hong Kong. Major practices were of use of PPE, working at heights, scaffoldings, electricity, housekeeping and work environment.

The literature review has revealed two research gaps that needed to be focused. First, the prospective safety performance evaluation on the basis of leading indicators like safety inspections, meetings and safety policy existence etc. Second, the use of field data in order to access the factual safety performance on the basis of operational practices on site. Lastly, in this chapter the key safety management factors and operational factors are listed down that will be used for the development of Performa.

2.2 SAFETY CULTURE OF ORGANIZATION

Construction safety management refers to the steps taken to improve the site safety. It requires to set up an effective system management system to improve the safety on construction sites. This system includes management, technical and regulatory practices that ultimately influence the construction safety. The safety management systems may differ from country to country on the basis of the set of best safety practices of particular region or the country (Ismail et al., 2011).Likewise, other management areas this requires planning, implementation, monitoring and control. In planning the organization should set up a safety culture by defining the attitudes, values, norms and policies that have to be followed by the organization and individuals (Lee 1996). A safety culture determines the management commitment towards safety of the construction workplace. The second approach that runs parallel to the safety culture is the safety climate. In simple words a safety climate is a result of setting a safety culture. It is defined as a perception of employees towards the work environment.

To define a safety culture for an organization is a complex task. There are several attributes of a corporate safety culture like management's commitment, workers involvement, development of a safety department and set up a policy and safety incentive rules (Molenaar et al., 2009). In order to achieve the safety goals of safety the safety management system has to be checked for its effectiveness through regular safety audits. Safety audits include regular inspections, safety plans reviews and safety meetings. Consequently, a progressive safety climate leads to safe work behavior at construction sites. Normally, worker's unsafe behavior are due to several factors like lack of safety knowledge, work pressure and organizations' abandoning behavior towards workers safety (Choudhry and Fang, 2008).

2.3 SAFETY PERFORMANCE EVALUATION

Safety performance is an integral part of safety management systems. The most common safety performance is in terms of safe actions and procedures on a construction site. There lies two concepts of evaluating the safety performance; retroactive approach related to accident rates while the pro-active approach is to analyze the safety climate, safety culture and awareness (Wu et al. 2015). The traditional method of measuring safety performance is based on accident frequency, accident costs and compensation insurance costs incurred on a project.

Construction is inevitably hazardous where workers may encounter different kinds of hazards that result into accidents. Construction activities are considered unsafe due to their complexity, uniqueness, interconnectivity and divergent site conditions from site to site. Most common accidents occurred on construction sites are fall accidents, struck-by and between, electrocutions, collapse, slips and trips (Chi and Han, 2012). Many studies have been conducted on safety performance on incident related data. Work place fatalities is not only referred to the developing countries but the construction business giants of the world also suffer from this short coming. The fatality rate of United States construction industry in 2012 was ranked number four with 16% of fatalities among all other industries (U.S Bureau of labor Statistics 2012) and similarly in Australia construction industry was fourth in fatality causing industries. In United

Kingdom one third of all workplace fatalities occurred at construction sites (Zhou et al., 2014). Syed M. Ahmad (2013) investigated a list of threats common on Pakistan construction sites. Major injuries faced by firms on construction sites, in descending order of their occurrence were fall injuries (55%), struck-by injuries (53%) , injuries by wastage and raw material (36%), heat strokes (33%) , head injuries (25 %), eye injuries (21 %) and burns (9%).

Lately, the retrospective approach has been disapproved by some researchers because they tend more to show the failure of safety management system. The modern approach refers to measuring the performance of safety management system in terms of effectiveness of safety culture, safety climate and safe work behaviors.

2.4 SUMMARY OF INTERNATIONAL STUDIES

Construction safety management has improved remarkably after the Occupational Health and Safety Act of 1970. It placed a law enforcement on contractors and employers to include construction safety in their core responsibilities (Hallowell and Gambatese, 2009). Despite of the improvement and enforcement of construction safety, the safety performance situation of this industry is still unfortunate. Mohurud 2013 showed the statistics of some of the developed construction industries like United Kingdom, Hong Kong and Singapore. Construction industry experience high fatality rates as compared to other industries. This is due to its dynamic nature, technology advancement, differing site condition, diverse human behavior and complex activities. Every construction project brings unique safety challenges to be accomplished.

Hinze et al. (2000) carried out a study to analyze the improvements furbished by safety that were foreseen through the implementation of zero accident techniques. A list of 170 such techniques were presented by the Construction Industry Institute report in 1993. The study identified whether these techniques have been adopted by the firms or not. Interviews were conducted on 18 different firms of large scale, focusing on the adoption and improvements made by the five most effective strategies of zero accident phenomenon. The five highly influencing strategies were namely; "planning for safety preceding a project or its task, Safety directions and training, safety motivation/reward programs, Alcohol and substance abuse programs and Accident investigations". The improvement on safety was determined on the basis of recordable injury rates of the firms over the years.

Construction Industry Institute (CII) conducted a study in 2002 named "Safety Plus: Making zero accidents a reality" which listed nine most effective applies to achieve world-class safety on sites. These practices are the base of all safety practices whether managerial or operational. Following are those practices; Management commitment, Recruitment for safety, Planning: pre-project and pre-task, Safety education: orientation and specialized trainings, Worker involvement, Assessment and recognition/reward, Subcontract management, Accident/incident investigations and Drug and alcohol test program. The study showed that construction industry shows dynamicity in the field of safety and continuous advancements and changes keep on occurring.

Hinze et al. (2002) found that safety approaches are more significant when they are implemented in form of networks. For example, safety meetings tend to bring more positive results when upper management keenly participates, there exists appropriate safety employments, and workers are involved in management and planning. The limitation of this study was that the pairwise interrelationships between different strategies were not considered, and their effects were not quantified.

In order to identify effective safety strategies it is first essential to find out the causes of safety non-compliance on all types of construction. A study by Abdelhamid and Everette (2000) described the three main accident causes with the use of accident root cause tracing method (ARCTM) as; inability to identify an unsafe condition before or during the progress of an activity, managements' decision to continue work even after the identification of an unsafe work condition and workers behavior to act unsafe willingly. The main reasons behind these root causes were lack of knowledge of workers, absence of managements' attention towards safety and concerning exclusively towards the completion of the job. Some of the common unsafe conditions that need to be considered were identified in this study, defective ladders, improperly constructed scaffolding, open sided floors, unprotected hazardous material etc.

Sherif Mohamed in 2002 explained that the workers' affirmative behavior is a result of safe climate, whereas safety climate is influenced by a set of factors including management commitment, definition of safety policy, safety and risk insight, workers involvement, work pressure and capability. A significant positive relation was supported between the safe climate and safe behavior. Management commitment had the most significant positive effect on the safety climate which ultimately encourages a safe worker behavior. Whereas, the work pressure held a negative impact on safe climate and behavior as the work pressure to complete task on time makes the worker unwilling to give safety a priority.

Toole (2002) conducted a survey among Architect/Engineers, General Contractor and Sub-contractors about who they consider responsible for site safety. The survey revealed a mixed perception of site safety responsibility among these key stakeholders. Author has suggested a solution to this problem by identifying the ability of a party to minimize the accident causing factors. For this there are eight safety non-compliance factors that cause accidents on construction sites. Lack of proper training, scarce efforts for safety implementation, unsafe work conditions, avoidance to use safety equipment and poor attitude towards safety were the factors initiating most of the on-site accidents. Based on the influence each party can play on prevention of the root causes, General Contractors' role in site safety is very high as most of the sub-contractors work under monitoring and coordination of GCs. The role of A/Es and sub-contractors is mixed. The author has suggested that safety prospects of each party vary according to type of contract and project.

In 2003 Huang and Hinze investigated one of the major accidents of the construction industry, fall accidents. They occur mostly on new construction of commercial buildings. Many questions regarding fall accidents like location where they occur the most, time of the day and workers' experience impact on falls ,were investigated in order to devise effective preventive measures to reduce fatalities due to fall accidents. Lack of safety trainings, misjudgment of workers and less flexible fall arrest system that cause hindrance in work were the major reasons that result in construction work fall accidents.

Hinze and Gambatese (2003) studied the factors that influence the safety performance of specialty contractors. The impact of General Contractors' or Construction managers' safety commitment plays a significant role in safety performance by the specialty contractors limited to the allocated work responsibility. Three main specialty contractor groups were surveyed for the factors that affect their safety performance. Reducing worker turnover plays the most positive role in safety and drug testing was recorded as second influential factor. Type of owner also triggers the safety performance of any specialty contractor as the owner may impose safety as a contractual condition.

Tam et al. (2004) examined the condition of construction safety in Chinese industry. The study details about various factors affecting safety from role of government to the safety risks related to activities. The survey based study gives an overview to understand the safety measures of an industry, factors affecting the safety and a set of suggestions to overcome the weaknesses.

S. Thomas Ng et al. (2005) discussed different safety performance evaluation methods that are used worldwide. Accident rate is the most commonly used method in which performance is measured in terms of accidents that took place over the span of worker-hours. The method has been criticized by many authors as contractors may show reluctance in reporting accidents honestly. Next is Incident Rate method where time delay or lost worker hours from an accident is the evaluation factor. It is also not considered a reliable mean of evaluating performance as the delays and lost worker-hours may be calculated in different ways in different scenarios. Experience modification rate refers to the cost that a contractor had to pay for workers' compensation insurance which has various methods of calculation and thus it also becomes an inappropriate method of safety performance evaluation.

As the study was conducted in Hong Kong the author discussed another method devised by Hong Kong construction industry, the Score Card method. In this method a set of six factors is established on the basis of which projects were rated. Score was allocated to each factor by an expert or the inspector. The drawback of this method was the question mark on ranking of the factors by different experts or inspectors each time. Further, it only accounts for the factors related to a particular project and on-site conditions where there is a strong need to evaluate an organization's safety factors as well. The study has developed a framework of safety performance factors ranked in importance by the three key participants of any project; client, contractor including sub-contractors, and the consultant through questionnaire survey.

A construction accident is a result of set of or series of factors that arise a situation contributing to an accident. Haslam et al. (2005) investigated 100 accidents in order to analyze the factors causative towards accident. A model was developed that explained that causation factors originate from organizational, managerial and design actions that give rise to instant on-site conditions such as unsafe worker behavior, lack of effective communications, unsafe working conditions and unsuitability of equipment. These instant conditions then result into an accident.

Safety management systems rely greatly on the interest and skills of the top management. Although in recent years safety has become one of the urgent concerns of the management yet there is a need to improvise the safety management systems with the increase in complexity and innovation in construction techniques. In order to identify the safety management systems' major elements, Teo et al. (2005) first identified the root causes of common accidents that occur on construction sites. Then these significant factors were assembled into a framework that may help the managers to ensure safety on construction sites. The framework formatted was based on four component factors; Policy factors, Process factors, Personal factors and Incentive factors. The author named the framework as a 3P+I framework.

Subsequent to the development of safety management system (SMS), Teo and Ling (2006) proposed that to improvise safety the safety management system must be assessed for its effectiveness. The authors suggested to develop an efficient tool through which firms' safety management system can be audited. By use of AHP and factor analysis technique 15 critical safety system elements were identified. A model was developed from these factors by applying the multi-attribute value model technique and tested for validation through actual site audits. This model quantified the effectiveness of an SMS in terms of Construction Safety Index of a site.

Navon and Kolton (2006) put an effort to develop a model for controlling the fall accidents on construction sites. Fall accidents are the most common and fatal in construction. For the development of automated model first step was to study the state of art practices being used in industry through site surveys and interviews. Most significant practices were use of guardrails and toe-boards, proper platforms, personal fall arrest system and safety nets. The model was developed into four modules. First identifies activity hazards, the level of hazard and schedule of the activity. Second module identified location of the activities and hazards. Third module deals with the protective measures e.g., location and conditions of guardrails and toe-boards. Fourth module conducted monitoring of the activities and preventive measures, comparisons of planned and actual schedule and reports generation.

Lin et al. (2008) made a workplace safety climate assessment with inquiring the workers of Chinese construction industry. In this study it was clearly explained that safety culture is the part of organization culture i.e., the business strategy. Whereas, safety climate is defined with the safety perception of workers and parties involved. Safety climate is the environment created actually on ground due to safety culture. Whereas, safety culture relates to the policies and efforts of organization. Survey was conducted among different groups of construction workers with respect to age, experience, level of accident proneness and organization. As a result seven factors were perceived as significant ones by the workers. The factors were safety awareness and competence, safety communication, organizational environment, management support, risk judgment, safety precautions and safety training. The authors have suggested to focus on relationship of safety climate and safety performance with occupational accidents and other safety features.

Aksorn and Hadikusmo (2008) conducted a research in medium and large construction sector of Thai construction industry. In this study critical success factors of safety program were identified. A list of 16 success factors were identified and ranked further by interviews and questionnaire survey. By the use of factor analysis, these 16 factors were grouped into four major categories; i) worker involvement, ii) safety management and control systems, iii) safety arrangements and management support. To validate the importance of these factors, three case studies were conducted and their performance was measured in the form accident frequency. Those projects who practiced most of the success factors were found to have less accident rate. This study provides influential managerial aspects to manage induce safety on projects from design till the completion. The three projects selected for validation were all large scale projects. Few of the project factors like cost and percentage completion were taken into account for selection of projects and their effect on safety performance was not considered in this study. Therefore, there exists a gap of highlighting the effect of project features on their safety performance.

Chinda et al. (2009) established a model for safety culture for construction industry. The model is based on the safety culture elements that play a significant role in development of safety culture and the goals that are expected out of a safety culture. Main groups of elements are policy and strategy factors, people factors, resource factors and factors including throughout the process.

For development of safety system it is essential to first identify and classify safety risks and then plan the mitigation measures as the foundation of the safety system. Hallowell and Gambatese (2009) conducted a study with the aim of identifying safety risks then identifying the safety factors that play role in mitigating those risks. The ability of each factor in alleviating a particular risk group was quantified with the help of Delphi Technique. Most influential safety program elements were management commitment, sub-contractor selection and management.

Molenaar and Washington (2009) formulated a framework to measure corporate safety culture. The study first defines the corporate culture in adherence to safety. It is a set of beliefs and norms set by the organization and well-kept in practice by the employees even if the membership changes. Safety corporate culture is affected by various factors that are grouped into three main attributes; people, process and values. Top management role, part played by the field personnel and sub-contractor selection were the people attributes. Process elements include safety plan and goals, assessment of safety system on periodic intervals, safety training, incentive and disincentive system. Safety commitment and safety behavior are the core values of a corporate safety culture. A hierarchal model of the above attributes was formulated that can be used as key indicators for measurement of a corporate safety culture.

Shapira and Lyachin (2009) discussed various safety risks regarding the tower cranes on construction site. Power lines, obstruction in viewing work zone for the operator, overlapping of cranes working at the same time on site, weather condition, language difference affecting instructions, congested site for proper movement of crane and type of loads are the project and environment conditions that play role of safety risks in tower crane operations. While, operator skills and experience, supervisors’ experience, site management, top management participation and lifting activity plan are the key human and management factors. Experts were interviewed to identify the most critical factors among these that hold an ample impact on tower crane safety on construction sites.

Many authors have commented that the small construction firms are likely to experience more accidents on their projects and large construction firms follow the health and safety management better than the small construction firms (Chi et al., 2005, Fernandez-Muniz et al., 2008). Cheng et al. in 2010 conducted a study to investigate the factors that aid in occupational accidents in small construction enterprises. The major factors investigated were lack of management skills for safety, values of employs towards safety and degree of acquiescence to safety legislation. From the survey some major reasons that result in accidents are; less experience of workers for an activity, weak health and safety management system, inability to provide personal protective equipment to the workers, workers avoidance towards use of PPE, ignorance of hazard signage and not obeying the protective safeguards on the site.

Various studies have been carried out to identify the impacts of most effective accident prevention strategies. It is anticipated that the effect of these strategies when applied in combination will bring even more immense improvement to the safety performance of construction sites. The interrelationship of the effective strategies was quantified through the Delphi technique by pair wise cross impact. Findings of the study revealed that the strategies; site safety manager, workers' involvement and participation, site safety plan and top management support had the most significant relationship impacts. For example when the site safety planning was done with workers' participation the safety was improved (Hallowell and Calhoun, 2011)

Esmaili and Hallowell (2011) examined the degree of safety practices diffusion in the US construction industry. For this purpose the authors first accumulated the most effective safety strategies through literature review. Then 58 firms were interviewed about those strategies. Diffusion of safety practices into the construction was studied on the basis of four models, namely internal model, external model, Bass model and Gompetz model. The results showed that out of 58 firms 67% adopted ten safety practices out of top 13. An overall 24 % firms has adopted an average number of safety practices. This study has depicted the true picture of safety advancement in the American construction industry. The authors have suggested that this study and models may show different dimensions with respect to specific features of an organization. Effect of other features alters the organization's safety culture which may not allow the firm to adopt some of the safety practices. This approach is taken as a basis for examining the actual state of safety applications in the Pakistan construction industry.

Ismail et al. (2012) explored dominant factors of safety management systems in Malaysian construction industry. An approach of five major factors is discussed, namely; Resource factor, Management factor, Personal factor, HRM/Incentive factor and Relationship factor. The study reveals the most influential factor that persuades the safety management system as the Personal factor which relates to the workers' safety awareness, education, experience, effective communication and competence. This study has initially discussed the fact that the safety management system factors may differ in importance in different countries and regions.

Zou and Sunindijo (2012) discussed the political skills required by a project manager or any level leader that help in implementing the safety procedures and consequently achieving a strong safety climate. For this purpose the authors have suggested four political skills that play a constructive role in ensuring a resilient safety climate. First, “social intelligence” which means that the leader understands the situations and behaviors around him quite well. This helps him understand the behavior of work-force and deal accordingly to create a sound media for safety climate to propagate. Second is the apparent sincerity which refers to the acts and attitude that reveal self-compliance to the safety which will motivate the organization members to follow the leader. These two skills help the leader in networking of diverse human resources and exerts a strong influence on the people by personal commitment to the safety goals. Study suggests that in order to generate a safe climate the firms’ should arrange political skills training along with the safety trainings.

Wanberg et al. (2013) investigated if there exists a relationship between safety and quality performance of construction projects. Empirical data from 32 construction projects about the safety and quality performance indicators were collected. Positive relationships between recorded injury rate and rework hours and first aid rate and number of defects were observed. To further validate this result interviews were conducted to know if project managers believe in this relationship between quality and safety. Some major similarities mentioned by the project managers and researches were; both require selective sub-contractor hiring and both address proactive management of risks. Safety has become the fourth crucial success element of a project along with cost, time and quality.

Hinze et al. (2013a) examined the relationship between best safety practices and safety performance of construction projects in United States. The study focuses on the safety practice as the percentage of projects that follow the safety practices. With this there emerged 20 best practices that were followed by 100% of projects. In the next step the study outlines 14 practices that differentiate the safety performance of these projects. For the measurement of safety performance recordable injury rates (RIR) were inquired. A correlation analysis of each of these practices with the RIR was carried out. Even out of these 14 practices there were three practices that showed the most significant negative relation with RIR. These three practices were incentive/ reward system for performing safe work, percentage score criteria obtained in safety trainings and investigation of near misses. However, the study implications are related to considering multiple aspects of differences in organizations and projects. Safety best practices for different size categories of organizations are needed to be specified.

In another study Hinze et al. (2103b) has compared the safety evaluation based on leading versus lagging indicators. Lagging indicators like accident rate are considered not very effective because these are more the results of safety non-compliance rather than safety performance. Leading indicators like management commitment, safety trainings and near miss reporting are top leading indicators. Near miss when recorded become the lagging indicator where as if past near misses are considered in planning it becomes a leading indicator. Leading indicators bring effective improvements where lagging indicators does not account for changes and improvements in the safety management framework.

Biggs and Biggs (2013) took a step forward by conducting a study on safety critical situations, the steps or conditions that give rise to unsafe conditions, safety management techniques and safety evaluation index. The authors spread the analysis on three interlocked projects. In first project, a matrix was mapped between safety critical acts and corresponding safety management techniques. A safety proficiency framework was developed from these two dimensions. In second project, safety behavioral factors and management skills that bring efficient safety culture implementation, were identified to add up in the framework. In the third project, the final and most essential step of evaluation was analyzed. The study has emphasized on the evaluation based on leading indicators rather than the lagging indicators of accident rate.

Rafiq M. Choudhry (2014) carried out a case study based work about an important component of safety management, behavior based safety. Behavioral safety has further two main components by which the general approach and perception of workers is noticed; safety compliance is the acceptance of self-safety measures during work and safety participation is how workers ensure safety working together. The study developed a framework to observe and manage the behavioral safety on construction sites. In the case study first an observation on common safety behaviors to find the pit falls of safety behavior that hinder the implementation of safety management system on sites. After that regular meetings to set and evaluate safety targets, safety reward system and instructions of safety through designed safety boards were some of the safety management practices inducted to improve the safety behavior on sites. As a result remarkable safety performance level were observed in the categories of personal protective equipment, housekeeping, working at heights, scaffold safety and plant/ equipment safety.

Mahmoudi et al. (2014) reviewed the eight safety management systems to develop a framework for continuous evaluation of safety issues and improvements on the construction sites. The eight SMSs' are OHSAS 180001, HSE-MS, ISO 4001 (Environmental Management System), ISO 50001 (Energy Management), ISO/IEC 27001 (Information Management System), ISO 20121 (Sustainable Events Management), BS 8800, AS/NZS 4801 (Australian Standard of Occupational Health and Safety Management System). All these systems had laid all emphasis on the seven main elements: "leadership and commitment", "policy and strategic goals", "organization, resources and documentation", "risk assessment and management", "planning", "implementation and monitoring", "measuring performance, auditing and reviewing". All these factors have a direct impact on safety of construction sites where each element has certain factors at each project level. The study has listed these factors as major elements of a safety system assessment model through 15 experts' and 75 construction industry participants' ranking.

Sinelnikov et al. (2015) conducted a study based on the use of leading indicators of safety to measure its performance. The study explained this theory in three steps. First, the level of knowledge about the leading indicators of safety among the construction industry OHS practitioners was measured. An expert panel was interviewed to find the management practices needed to imply the leading indicators in safety management. Finally, the causes of unacceptability and hindrance in the application of leading indicators were identified. It was revealed that the leading indicators require management commitment and technical knowledge of top management to be exercised across the organization.

Rajaprasad and Chalapathi (2015) stated the situation of Indian construction industry where safety management system is neglected. To enforce the safety implementation in the industry the legislation has forced the firms to get the OHSAS 18001 applied. It is a safety certification that has ruled out the required health and safety policy, hazard management, training and communication practices to be observed by the organization. The observance of OHSAS 18001 has shown a significant effect on safety culture, safety behavior improvement and safety trainings. The implementation of OHSA 18001 is characterized by the management's commitment and safety policy set by the organization.

Zhuo et al. (2015) gave a systematic review of the construction studies carried out so far. A cluster of studies were reviewed and categorized on the basis of year, journal title, project type and phase, innovative technology applied for safety and research topic. The review identified three major features of construction safety; the flow of safety innovations and evolution of safety management systems, the analyses of behavior based and organizational safety culture and the approaches of safety performance evaluation. The study has provided with a collection of diverse studies related to safety in different perspectives. One of the important findings of this study was the research gap in coordination of two perspectives of safety implementation; the management perspective and the technology or practices of construction site safety.

Wu et al. (2015) conducted a systematic structure equation modelling approach to carry out prospective safety performance evaluation of Chinese construction industry. Three types of firms were taken under study; state-run firms, private enterprises and joint ventures. This approach of safety performance relies on leading indicators rather than lagging indicators like accident rate, compensation cost and delays. These measures are actually the result of failure of the safety system. In prospective approach a cause-effect relationship of safety factors and targets are studied which provide the management with a pro-active insight to safety system and enables improvements. Four aspects of safety performance discussed in this study were safety climate, safety culture, and safety attitude and safety behavior. Various sub-factors create impact on these four aspects which consequently validate the performance of safety management system.

Major recommendations from the reviewed literature were;

- To use the prospective safety performance evaluation that will bring light to the influence and knowledge of the leading indicators of safety performance in the construction industry,
- To analyze the extent of agreement between these optimistic indicators and on-site actual practices essential for construction site safety and
- To identify the reasons behind the safety non-compliance and negative safety behaviors.

2.5 SUMMARY OF NATIONAL LITERATURE REVIEW

Pakistan construction industry is experiencing a rapid growth in in terms of development and technology. With this growth have come many complexities and challenges that need to be administered. Construction safety is one of the crucial aspect growing sideways to the advancement. In many developed countries, safety has become one of the project success factors in addition to the time, cost and quality efficiency. Whereas, in Pakistan it is still the least concern of stakeholders as compared to enhancing quality and reducing time and costs (Zahoor et al., 2015). Safety has yet to be responded with a sound framework and governing body that enforces the safety interventions into the construction process. Many studies have been conducted by the academia to provide with the framework and management recommendations to the field. This share of study discusses the efforts that has been made to facilitate awareness and diffusion of safety practices to the industry.

Major accidents that occur in Pakistan construction sites ae due to falls, struck-by falling objects and wastage material on sites, electrocution and caught in between incidents (Farooqui et al. 2007, Hassan 2012, Nawaz et al. 2013) .Some major reasons that were identified through this study were; lack of a country-wide safety managements system due to scarce construction management practices, lack of awareness about safety among workers and top authorities as well, inadequate compensation schemes that does not support safety as a basis of business survival and inability of the regulatory authorities to enforce safety as a part of project success (Farooqui et al. 2007). Another factor is the unavailability of skilled workers and high unemployment ratio in the country (Jafri et al. 2012)

In 2008, again Farooqui et al. investigated some of the construction sites to identify major safety areas where the Pakistan construction industry is failing and thus experiencing on site incidents. The investigation showed that the major safety failure in this industry is the lack of self-protection aspect among workers due to lack of awareness of their own safety. The second major fault was the site management who did not seem to put an interest in creating an obligation of personal protection to the workers. The study has ranked the safety performance of observed sites on the basis of some major safety practices selected, which were related to personal protection, housekeeping, scaffold operations and access to heights. The safety performance indices showed that building sector lies at an average safety performance. Another major fact revealed in the study was the lack of any data collation system related to safety which is due to absence of a standard system for safety management. Many other reasons are cause of safety failure including lack of governing body, political instability resulting in non-existence of a safety policy, setting the cost as prime priority and considering the human life as least important, less wages to the workers, lack of qualified safety supervisors, no implementation of safety education certificate occupation by the workers and behavior differences about safety among the workers (Farooqui, 2012; Raheem et al., 2011; Saqib et al. 2010; Choudhry et al. 2012 and 2006)

Syed M. Ahmed in 2013 investigated the Pakistan construction industry for evaluating the safety performance and improvement techniques to be applied to overcome the obstacles in the way of safety compliance. Various safety system elements were investigated to check the level of awareness and agreement by the people involved in construction industry. The author has included proactive safety factors to the safety improvement framework like management commitment, safety rules, effective communication and worker involvement. These factors build up a safety climate which gives rise to the safe work environment on sites.

Safety climate is not yet well-established in Pakistan construction industry. Many researchers have spotted a lack of strategic safety climate framework. The significant factors of safety climate that are recommended to enhance the safety performance of the construction industry include management commitment and workers' involvement (Choudhry and Masood, 2011), allocation of safety budget for trainings, appointing a qualified safety inspector, eliminating the misconceptions regarding safety practices among workers and contractors, development of a safety regulatory body and establishment of effective communication channel (Memon et al., 2013; Nawaz et al., 2013; Hassan 2012)

Safety has got the consideration in research from almost a decade, in Pakistan, and yet it is not up to the level where safety condition of construction sites can be marked as satisfactory. According to Pakistan Bureau of Statistics annual report 2012-2013 the incident rate of Pakistan construction industry has in fact increased from 14.55% in 2006 to 15.24% in 2012 (Zahoor et al., 2015). This shows the clear picture that there still exists a major gap in safety intervention studies. Major recommendations by the national authors have been emphasizing on studying the causal relationship of various safety factors and actual practices, use of structure equation modelling and social network analysis to safety data validation, measuring the applicability of features of successful safety management systems in Pakistan construction industry and studying the unsafe work behavior of workers.

Chapter 3

ANALYSIS OF CONSTRUCTION SAFETY IN PAKISTAN

3.1 INTRODUCTION

To elevate the safety performance of Pakistan Construction industry there is a need to first develop a system of safety evaluation for current level of safety practices being followed. For this purpose a set of best or most easily followed safety practices at both firm and site level has to be enlisted and categorized. These practices will improvise the safety climate of a firm which in result will ensure better safety performance on sites. One of the objectives of this study are to analyze the current state of construction industry with respect to safety performance of projects under construction. This will be achieved by first setting up a list of most required safety measures to be practiced by a firm on its project site, and then analyzing the observance of various projects to the safety measures achieved from literature study. State of the art safety measures and practices are ranked on their level of effectiveness on safety of a project. Whereas, the current scenario of Pakistan construction industry is assessed on the basis of existence and non-existence of these measures. This chapter explains this analysis with detailed steps.

3.2 STATE OF ART SAFETY PRACTICES

In conducting an analysis of current safety condition of the construction industry, the first step is the identification of the key safety measures required in building a safe work climate. Modern approach towards safety is inclined in preparing a safety management system indulged from inception of a project. This includes the preparation of both management practices and practical measures to be executed during construction. Both management and operational safety measures work collectively. If even one is not proper the other will not create any difference. A cluster of national and international researches have been thoroughly studies to identify a set of most significant safety practices for both management and operation level. Safety codes of some of the important construction industries in the world were also consulted, to confirm the applicability of these research based safety measures.

Typical safety measures at management level of a firm include the safety department and its organization, communication and duties throughout the project development. Arrangements that need to be made for ensuring safety resources and the success of safety plans. Skills required for safety commitment from top to lowest level play a major role in keeping safety intact at different levels and types of construction. Safety on site is in fact a testimony of the safety management system. It will not be wrong to say that a safe work site is considered as the credential of the firm's safety management policy.

Work-site safety is related to the possible hazards that can occur in various activities of construction. It is basically planned in the management portion where hazard management identifies the hazards and plan the mitigation measures accordingly. It is evident that the main unit under the threat of hazards is the work force. Therefore, typical safety measures on site are mostly the PPE provision that hinders most of the work related hazards. Considering the safety in subjective approach, the safety measures are typically based on the level of hazard to which each activity is prone to. Based on the extensive literature studied most accidents were falls (Huang and Hinze, 2003; Mohurd, 2014) then electrocution, struck by objects falling from heights, on-site traffic etc.

An accident on work place may have a network or mesh of causes underneath. In simple words an accident may occur as a result of an unsafe condition. An unsafe condition is described as any activity or condition that violates the safety standards that are set for any specific work or location. It can be the absence of safe activity layout, unsafe state of tools, workers' anti-safety behavior or the unsafe manner of performing a particular work activity (Tariq S. Abdelhamid, 2000; Toole, 2002). Different theories have been studied that explain the causes of origin of these unsafe conditions that lead to safety compromise. An old theory explains the unsafe conditions as mediator factors while the underlying root causes are related to the ineffectiveness of the management system. Summing up the discussion it explains that on-site safety measures are the preventions to eliminate unsafe conditions. While the management systems, policies and duties plan and enforce these preventions as an effort to address the root causes of any mishap.

3.3 SAFETY CULTURE & PERFORMANCE FACTORS

As explained above a complete safety management system consists of safety climate, culture, attributes and performance. Management policy, department, organization and goals, communication, monitoring and implementation define the safety climate of a firm which has a thru effect on safety culture (Ford and Tetrick, 2008; Biggs and Biggs, 2012). Safety culture relates to the behavior and perception of workers and teams towards the safety climate. This is achieved through trainings, prioritizing safety as an important performance criteria and objective, responding to safety through feedbacks, reports, investigations and meetings and by acquiring qualified supervisors to implement safety on site. The effectiveness of the management framework can be assessed through the safety measures/attributes practiced at site. The performance of this complete safety management system relies mainly on the safe site operations (Hsu et al., 2012). In a nutshell, the main components of a safety management system (SMS) are;

a) Managerial Framework of Safety

b) Operational Framework of Safety

Both of these are further divided into categories and each category contains its elements. These are attained from extensive review of research and safety codes of some renowned construction industries. All these categories and elements are explained and enlisted below.

3.3.1 Managerial Safety Framework

The management framework contains all the firms' management efforts and skills, its policies and actions to be taken. The practices contains the rules and goals set forth for ensuring safety on the site.It is considered as a pro-active tool of ensuring safety (Choudhry et al., 2014; Wu et al., 2015). The framework considered in this study is divided into further categories which are;

1. Safety Management Policy:

    i) A written safety policy by the firm

    ii) A separate safety department

    iii) Authorities and responsibilities of safety department members are clearly written in the policy.

    iv) Safety goals are set and fully clear to safety department members.

    v) Safety performance of contractor/subcontractor on their previous projects to be included in their selection criteria.

    vi) Safety policy and safety plan required as compulsory document in the bid.

    vii) A worker hour restriction in the agreement.

2. Safety Enforcement:

    i) Safety Training and meetings on regular intervals.

ii) Safety inspections on regular intervals.

iii) Safety is given priority in visits by the head office personnel.

iv) Tool Box Meetings on site regularly.

v) Safety representative is designated with the authority to stop work if he finds any unsafe condition until prevented.

vi) Safety resources allocated in terms of time and cost in schedule and budget.

vii) Personal Protective Equipment provision to workers.

3. Safety Climate Integration:

i) An effective communication channel throughout the safety crew and among safety and other crews.

ii) Punishment/ Reward system.

iii) Appointing qualified supervisors.

4. Safety Review:

i) Safety program reviewed periodically for effectiveness check and improvements required.

ii) Workers' experience and feedback involved in preparations and review of safety plans

iii) Physical and mental examination on appointment and on periodic surprise intervals.

iv) Drug test on site on surprise inspections.

5. Hazard Management:

i) Job hazard analysis; identification and response planning of safety risks, conducted prior to commencement of job on site.

ii) Encouragement to report near misses.

iii) Proper investigation and report mechanism for near misses as well as accidents.

iv) All installations; scaffold, lift, cranes, machinery, not permitted to use without a permit from qualified inspector at the time of installation, every week and upon a severe weather condition exposure.

A comprehensive list of managerial safety factors sets up the resulting safety culture which modifies the safety behaviors and motivates the safety compliance. In a prospective approach safety culture gives rise to a positive safety performance thus depicting a directly proportional relation between the two. Clarke (2006) and Christian et al. (2009) conducted a comprehensive meta-analysis on safety climate and safety performance and indicated that safety climate is a vital factor affecting safety performance in a directly proportional relation.

Table 1: Managerial safety factors

SR#	CODE	DESCRIPTION
		MANAGEMENT COMMITMENT
1	M-MC1	(safety policy)
2	M-MC2	(safety department)
3	M-MC3	(safety roles and responsibilities)
4	M-MC4	(safety goals and objectives set)
5	M-MC5	(safety performance in selection criteria)
6	M-MC6	(safety plans and policy in bid documents)
7	M-MC7	(work-hour restriction agreement)
		SAFETY ENFORCEMENT
8	M-SE1	(safety trainings)
9	M-SE2	(safety inspections and audits)
10	M-SE3	(safety as priority in head office visits)
11	M-SE4	(daily tool box meetings)
12	M-SE5	(safety officer authorized to stop unsafe work)
13	M-SE6	(safety resource allocation)
14	M-SE7	(PPE policy)
		SAFETY CLIMATE
15	M-SC1	M-SC1 (effective communication channel)
16	M-SC2	M-SC2 (reward/punishment system)
17	M-SC3	M-SC3 (qualified supervisors on site)
		SAFETY REVIEW
18	M-SR1	M-SR1 (Periodic safety plan review for improvements)
19	M-SR2	M-SR2 (workers' experience & feedback in safety plan)
20	M-SR3	M-SR3 (physical & mental examination of workers)
21	M-SR4	M-SR4 (drug-test policy)
		HAZARD MANAGEMENT
22	M-HM1	M-HM1 (Job hazard analysis prior to commencement)
23	M-HM2	M-HM2 (Reporting near misses)
24	M-HM3	M-HM3 (Fair & timely accident investigation and report)
25	M-HM4	M-HM4 (Temporary installations' use permit by inspection)
26	M-HM5	M-HM5 (Temporary installations' weekly inspections)
27	M-HM6	M-HM6 (Temporary Installations' inspection upon sever weather exposure)

3.3.2 Operational Safety Framework

Considering the theory of prospective approach, the safety performance is positively dependent on its safety climate and culture at firm level. As both these motivates safety behavior and improvise the adherence of safety attributes to common project construction. In simple words the factor describing the "integration of safety resources in budget and schedule of project" will provide the management with cost of PPE, safety signage, safety equipment and tools and the schedule will be able to incorporate the meetings, inspections and trainings to ensure the safety measures are being applied to full adherence.

Conventional measures of safety performance were the incident rate, accident occurrence per work-hours and compensation costs. These approaches were later on criticized by researchers as the measure of loss rather than safety and is referred as the reactive approach. Therefore, the prospective approach relies on the safety management system components; safety climate, culture and the resulting safety behavior in form of compliance to the safety measures and rules during execution. Taking the safety documentation and commitment to the practical form is the real task where safety performance is seen. In this study, safety performance of firms are measured through the level of compliance to developed Performa of safety management framework and operational framework.

On-site safety measures are mostly common among different construction industries. Important studies and codes studied are; Construction Site Safety Regulations Hong Kong(2003), U.S Army Corps of Engineering Accident Prevention Control Checklist(2014), (COHSMS) Guideline by JCOSHA, Construction Work- Code of Practice; Safe work Australia (2013), Construction Safety Regulations, 4th edition 2010; Government of Dubai, Hammad al Mebayedh(2013), ENSIGN Driving to zero injuries and accidents (2007), Guide to Safety, Health and Welfare at Work Regulations Ireland (2007), Safety, Health and Welfare at Work Regulations- HSA (2013), OSHA 2236 Material Handling, OSHA 3075 Electric Hazards, OSHA 3106 Masonry and Concrete, OSHA 3124 Ladders, OSHA 3150 Scaffolding, PPE Selection Guideline OSHA. On-site safety guidelines are based on each step of construction ranging from basic site conditions, safe excavation, concrete works, work at heights safety provisions, PPE guidelines and usage policy, material and installations organization steps and procedures. The safety checklist developed to be surveyed on the site were related to these steps and portions of site and construction:

i) Site conditions for workers

ii) Safety through PPE

iii) Excavation safety

iv) Ladders safety

v) Lift safety

vi) Safety at heights

vii) Scaffold Safety

viii) Safety through house-keeping

Table 2 shows the list of operational measures that are considered with respect to each level of construction. These are the direct indicators of how sound an organization's safety culture is. The primary link between managerial factors and operational measures is that the managerial factors ensure the practice of operational factors on site.

Table 2: Operational safety factors

SR#	CODE	DESCRIPTION
		SITE CONDITIONS
1	O-SC1	(On-site first aid facility)
2	O-SC2	(Contacts/Communication channel display on site)
3	O-SC3	(drinking water)
4	O-SC4	(rest shelter)
5	O-SC5	(food platform at or near site)
6	O-SC6	(sanitation)
7	O-SC7	(smoking prohibition on site)
8	O-SC8	(safety signage and policy display on site)
		PERSONAL PROTECTIVE EQUIPMENT
9	O-PPE1	(head protection)
10	O-PPE2	(hand protection)
11	O-PPE3	(Foot protection)
12	O-PPE4	(High visibility jackets)
13	O-PPE5	(Fall protection system)
14	O-PPE6	(Eye protection)
15	O-PPE7	(Protective Clothing)
16	O-PPE8	(Hearing Protection)
17	O-PPE9	(Respiratory Protection)
		EXCAVATION SAFETY
18	O-E1	(Shoring use designed by engineer/qualified person)
19	O-E2	(Excavation warning signs to inform visitors/ workers)
20	O-E3	(Guard rails around the excavation)
		LADDER SAFETY
21	O-L1	(Ladder design based on standard measures)
22	O-L2	(Ladders mounted on proper foundation)
		LIFT SAFETY
23	O-LS1	(Regular lift inspection and repairs)
24	O-LS2	(Lift area secured from unauthorized access)
25	O-LS3	(Lifting capacities enforcement)
		SCAFFOLD SAFETY
26	O-SS1	(Scaffold on stable foundation)
27	O-SS2	(Safe access to scaffold)
28	O-SS3	(Safe work platform on scaffolding)

Table 2: Operational safety factors (continued)

29	O-SS4	(Guard rails and toe-boards around work platform)
30	O-SS5	(Screening nets around scaffold exterior)
31	O-SS6	(Weight capacities of tools, materials and worker strictly followed and displayed)
		SAFETY AT HEIGHTS
32	O-SH1	(Mandatory use of full body harness when at heights)
33	O-SH2	(Openings of structure and at ground covered)
34	O-SH3	(Safety nets and guard rails for openings at height)
		SAFETY BY HOUSEKEEPING
35	O-HK1	(Toxic substances at 1.5 m from work area and electricity)
36	O-HK2	(Electric wires and installations mounted on insulators)
37	O-HK3	(Electric supply and distribution boards secured properly)
38	O-HK4	(Clear and Clean walk ways on site)
39	O-HK5	(Fire extinguishers on site)
40	O-HK6	(Material wastage and debris disposed of from site)
41	O-HK7	(Excavated loose material dumped at least 2m away from excavation edges

3.4 PERFORMA FOR SAFETY PERFORMANCE EVALUATION

A Performa was established based on all the safety measures to be taken on firm and project level, as discussed above. Majorly, the questionnaire had four main fragments namely; personal information, project related information, management framework and operational framework. A total of 56 questions were asked on whole. Below, these four main headings are explained further:

a) Personal Information:

  i) Name

  ii) Organization

  iii) Experience

  iv) Safety knowledge

b) Project Factors:

   i) Project Nature

   ii) Project Cost (Ranges)

   iii) Project location

   iv) Skilled/ Unskilled Staff on the project

   v) Work-hours

   vi) Firm experience (years)

   vii) Number of sub-contractors involved

   viii) Project duration (months)

   ix) Type of Client

   x) Existence of Safety policy by Client

Many of the respondents hesitate in sharing the name of the contractor firm and the exact cost of the project, therefore costs is asked in different ranges of contract sums. Type of Client is to know the nature of organization whether public, private, foreign or semi-government.

c) Management Framework factors:

   This contains five main attributes and 25 sub-attributes in them. The management framework safety factors are explained in the section above.

d) Operational framework factors:

   This portion consists of eight main points of safety vulnerability on the site during construction. The safety checklist is developed to be surveyed on the site related to these steps and portions of site and construction:

3.5 DATA COLLECTION

Evaluation of the safety conditions prevailing in Pakistan construction industry is conducted through physical site surveys and importance based factors ranking. The first phase of data collection achieved the development of Performa (a checklist) based on safety measures at management and site level.

After the development of Performa, ranking of factors is achieved by interviewing researchers and field people and also through online responses. The questions were formulated in a way of asking how much importance does a particular factor lays on the safety performance of a project. The respondents answered on Likert scale of 1-5, based on their experience. Where each score represents its importance in overall safety performance i.e., 1= very low, 2= low, 3= moderate, 4= high and 5= very high with maximum importance

To fulfil the motive of evaluation of safety situation in Pakistan construction industry, field data was collected. It started with locating different projects that were under construction in three major cities Rawalpindi-Islamabad, Lahore and Faisalabad. For the evaluation of safety culture at firms' level, contractor offices were contacted. For the collection of projects' data the same questionnaire was used as an inquiry of the presence of enlisted safety factors. Safety practices are analyzed at both management and site level. Safety in organization management evaluates the safety culture in firms whereas the operational (on-site) safety gives the safety performance of projects carried out by those firms. For safety culture data, the interviewees were Project Managers, Safety Managers and Deputy Safety Managers. The interview sessions lasted around 45-

60 minutes. The documents, reports other printed material that were required to support the answers to the particular questions were also viewed thoroughly.

In the next phase, of safety performance evaluation, the project sites were visited in personal. The safety supervisor or site engineers on site were asked some random questions from which the safety practices followed depicted. As the nature of survey was based on a critical topic, some respondents on site were reluctant to give true picture regarding the phases which were completed. To counter this, some trick questions were asked by giving a scenario and asking what would be their response plan for that. Also, it was asked to show any supporting material like photographs, safety notice or plan for some of the activities that could not be seen at the time of visit. The site investigations took 3-4 hours depending on the size and nature of projects. Some major projects were visited twice and thrice in order to investigate the safety practices of some major milestones during construction e.g. crane installation and dismantling, roofing and installation of scaffolds. These repetitive visits were arranged by the contractor representatives themselves in order to promote the safety practices they followed. This was a big encouragement in the development of this study.

3.6 STUDY METHODOLOGY

To evaluate the projects with respect to their safety culture and safety performance on sit, first the score of listed down factors was calculated. Rank of each factor was calculated by using the mean ranking formula (Ng et al., 2001). Given the equation for mean ranking of any factor is:

$$R = \frac{\sum S.Si * f}{N} \quad (3.1)$$

Where, R= mean score of a factor

S.S= score on the Likert scale (i= 1, 2, 3, 4, 5)

F= frequency of each score in responses

N= total number of responses

Once both the factors' ranking and projects based data were achieved, the safety climate evaluation and safety performance of each project were calculated, separately, in form of final score achieved by the existence or non-existence of the enlisted safety factors. Considering existence = 1 and non-existence = 0 and score of a factor is given by R, the safety performance score of a project was calculated as summation of (existence/ non-existence * S) for all factors. For example a factor holds score of 3.62 and it is existent in a surveyed project the safety performance score for that one factor becomes (1* 3.62). Whereas, in the same project a factor of score 4.1 was absent (non-existent) the score is given as (0* 4.1). Similarly considering the same for all enlisted factors of Performa the final equation for calculating the safety performance score of any project is given as:

$$SPS \ or \ SCS = \sum (R * E)\ i \quad (3.2)$$

Where, SPS = safety performance score, SCS= Safety climate score

R = score of each factor

i= safety factors enlisted

Both the scores are then compared to analyze the conformance between both aspects, safety in management (safety climate) and on-site safety (final safety performance). Moreover, the projects were ranked relatively in a form of very low, low, medium and high safety performance index. For relative safety index, the safety performance scores attained by each project were divided by the total score of considered factors. The relative safety index (SI) score are calculated as:

$$SI = \frac{\sum (R * E)\, i}{\sum Ri} \tag{3.3}$$

With this equation the relative score of each project's safety performance came out to be in the range of 0-100. To rank the projects, this range was further divided into four categories of level of safety performance. Where, score of (0-25) referred to very low safety performance, (26-50) as low, (51-75) as medium and (76-100) as high safety performance. To examine the adherence between the safety culture of organization carrying out the project and the safety performance on site, descriptive statistical analysis was carried out.

3.7 RESULTS

3.7.1 Online Questionnaire results

Two types of data were collected for factors ranking; the online surveys and the interviews. Under the technique of non-probability convenient sampling, a total of 45 responses were collected. Among which 5 (11.11%) were from academia. The rest of 40 respondents were from construction field. Among these 25(55.56%) of the respondents had experience of 20 years or more while rest of them (33.34%)

had minimum 15 years of experience as shown in Figure 2. Each of them was asked to rank factors as per their importance perceived for achieving safety in construction.

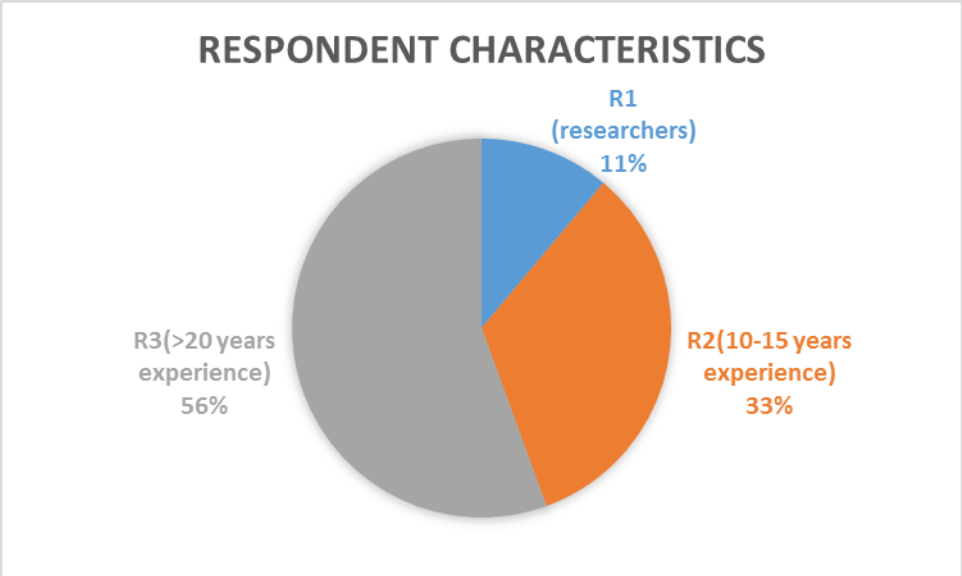

Figure 2 Respondent Characteristics

The targeted respondents were those who have academia or field experience purely of Pakistan construction industry. This limit was selected to achieve results that can are based on actual state of Pakistan construction industry. Another trait that was inquired about respondents was any safety training or certification acquired by them. Only 8 of them had some kind of safety training or certification like NEBOSH International certificate in construction health and safety, OSHA USA certification, HSE officers' course and HSE managers' course. Figure 3 shows the level of understanding and compliance/experience in construction safety techniques.

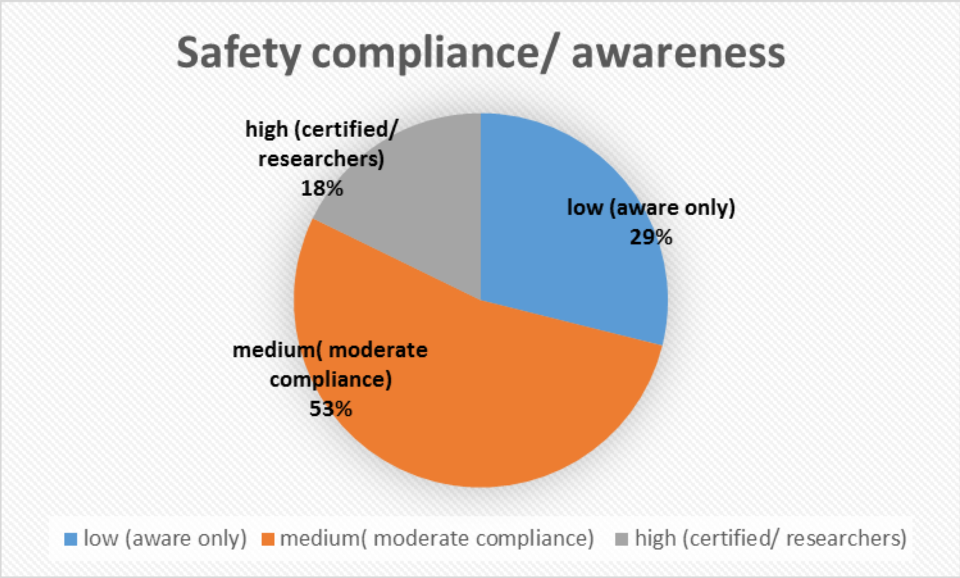

Figure 3 Safety Awareness of Respondents

It is evident from the ratio of respondents that most of them on average or below average line with safety compliance and experience in the field. 29% (13) respondents have very low knowledge about safety practices and techniques for the construction. Here, low means that they have understanding about safety importance and measures but not applied this knowledge in their experience to a remarkable level. Respondents with medium awareness (53%) were not only aware with safety in construction but they had applied it in their experience to a moderate level. In the category of high, researchers and those respondents who had any of the above discussed certification were included. Using the response data and mean score calculation technique, weighted average score of each factor was calculated in order to measure the safety performance at both organization and site level. Table-3 shows the score of each factor contributing in safety culture of organization.

Table 3: weighted average score- managerial factors

CODE	*SCORE:*	*1*	*2*	*3*	*4*	*5*	*Weighted average*	*RII*
M-MC1		4	7	8	10	16	3.60	0.720
M-MC2		8	4	13	15	5	3.11	0.622
M-MC3		5	5	15	10	10	3.33	0.667
M-MC4		7	3	11	8	16	3.51	0.702
M-MC5		6	7	11	9	12	3.31	0.662
M-MC6		5	5	13	8	14	3.47	0.693
M-MC7		6	4	14	13	8	3.29	0.658
M-SE1		7	5	12	10	11	3.29	0.658
M-SE2		8	3	6	13	15	3.53	0.707
M-SE3		3	8	9	10	15	3.58	0.716
M-SE4		8	6	11	10	10	3.18	0.636
M-SE5		6	3	4	14	18	3.78	0.756
M-SE6		7	5	9	11	13	3.40	0.680
M-SE7		0	5	7	15	18	4.02	0.804
M-SC1		4	6	7	17	11	3.56	0.711
M-SC2		6	3	10	11	15	3.58	0.716
M-SC3		6	4	5	15	15	3.64	0.729
M-SR1		7	9	11	9	9	3.09	0.618
M-SR2		10	8	11	9	7	2.89	0.578
M-SR3		8	7	13	9	8	3.04	0.609
M-SR4		16	7	6	10	6	2.62	0.524
M-HM1		3	4	5	22	11	3.76	0.751
M-HM2		3	4	9	17	12	3.69	0.738
M-HM3		6	7	10	13	9	3.27	0.653
M-HM4		1	4	10	17	13	3.82	0.764
M-HM5		5	4	9	14	13	3.58	0.716
M-HM6		**4**	5	13	13	10	3.44	0.689

Based on the weighted average of each factor, their relative importance index (RII) was calculated by dividing the weighted average with its maximum score i.e. 5. Considering the factors with respect to their related category, a general trend of their importance can be seen. An overall trend of most important factors prioritizes the categories as well. Top five most important factors belong to safety enforcement strategies and hazard management. Then management commitment which refers to policies and safety rules of sub-contracting. The most important factors is related to safety of temporary installations due to higher fall accidents ratio in construction (Mohurd 2014)

1. <u>Management Commitment:</u>

Among the seven sub-attributes the top three most important factors were Safety Management policy development (M-MC1), Clear safety goals set prior to commencement of job (M-MC4) and Safety policy and plan as compulsory bid document (M-MC6).

Figure 4. Management Commitment

2. Safety Enforcement:

Three most influential factors in safety enforcement step are the Provision of Personal Protective Equipment (PPE) (M-SE7) with an overall highest score of 4.022, Safety representative authorized to stop unsafe work (M-SE5) and Safety given priority in head office visits (M-SE3) respectively.

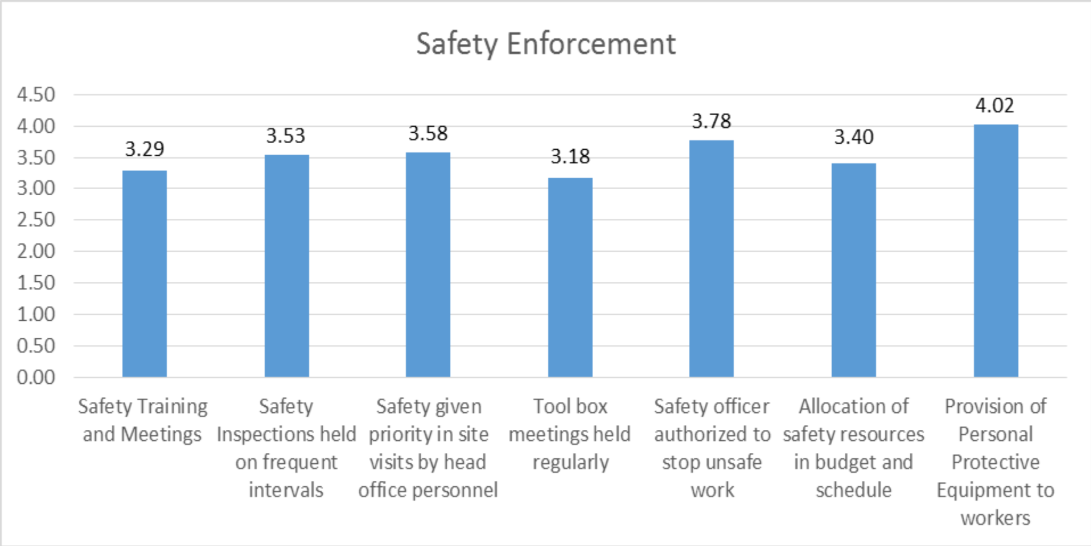

Figure 5 Safety Enforcement

3. Safety Climate Development:

Safety climate consisted of three factors and the factor which contributes the most in developing the safety organization culture is the appointment of qualified supervisors (M-SC3) on site.

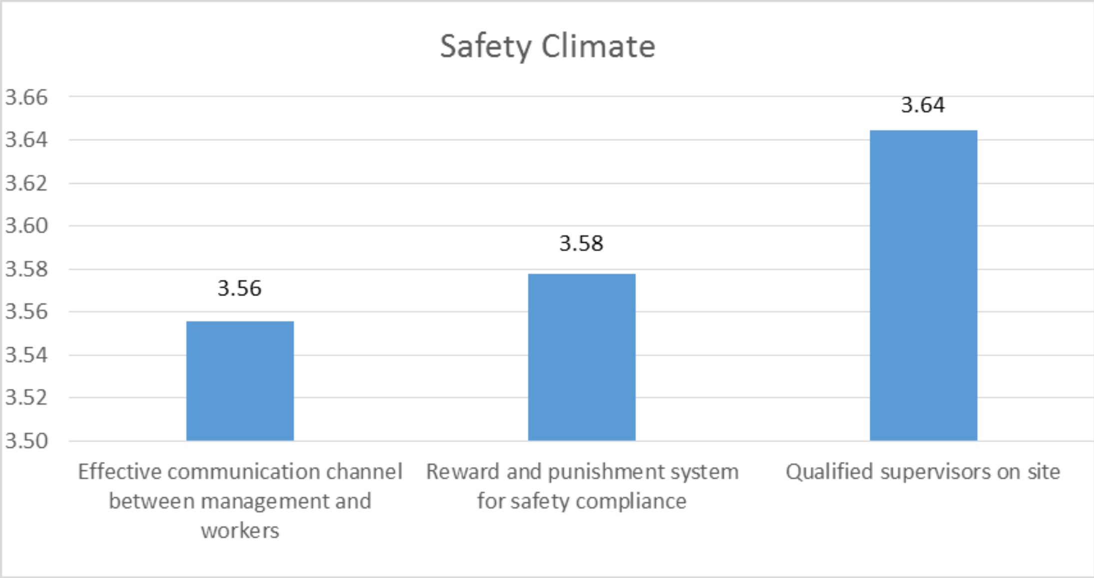

Figure 6 Safety Climate development

4. <u>Safety Review:</u>

Workers experience involvement in development of safety plans (M-SR1) plays an influential role in the safety organization culture development according to the weighted average score. The second most important was the Physical examination of workers (M-SR3).

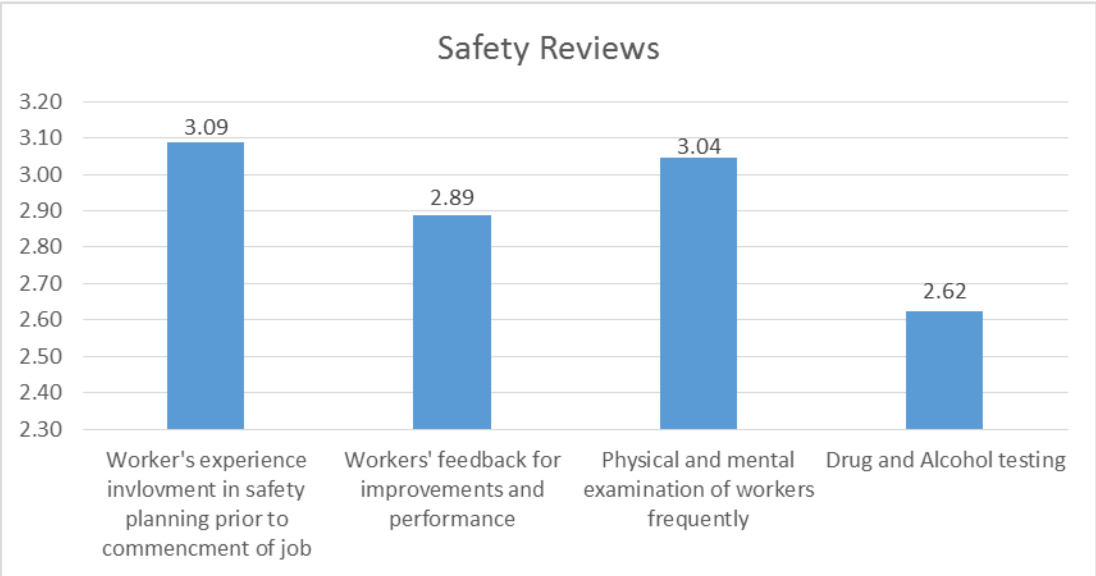

Figure 7. Safety Reviews

5. <u>Hazard Management:</u>

The top three factors are temporary installations' inspection before use permit, job hazard analysis and reporting near misses.

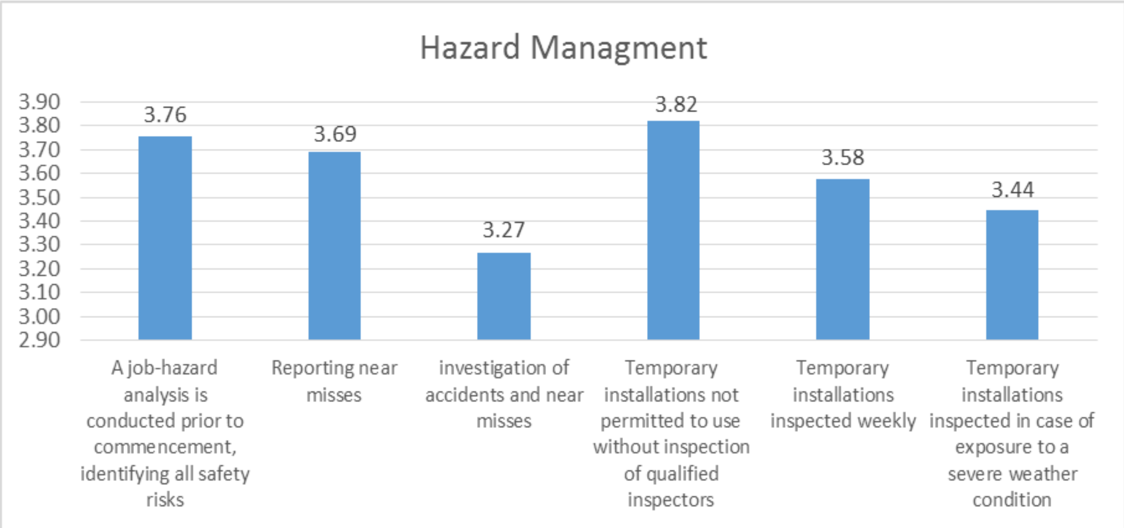

Figure 8. Hazard Management

The results gave a base line to which the current situation of the industry will be compared. Similar to the factors of safety culture, the scores of safety factors of site are as also calculated on the same method. But these factors are not prioritized on the basis of score as each individual factors' score was considered in final performance score as per its existence found on the site or not. Table 4 shows the scores of each site safety factor as following:

Table 4: weighted average score of operational factors

SR #	SCORE	1	2	3	4	5	Weighted average	RII
	CODE	no. of responses for each						
		Site Conditions						
1	O-SC1	0	0	11	15	19	4.18	0.836
2	O-SC2	4	10	11	11	9	3.24	0.649
3	O-SC3	0	0	7	17	21	4.31	0.862
4	O-SC4	0	0	8	17	20	4.27	0.853
5	O-SC5	0	0	9	15	21	4.27	0.853
6	O-SC6	0	0	19	17	9	3.78	0.756
7	O-SC7	0	5	9	19	12	3.84	0.769
8	O-SC8	3	4	11	13	14	3.69	0.738
		Personal Protective Equipment						
9	O-PPE1	2	1	2	8	32	4.49	0.898
10	O-PPE2	1	3	7	24	10	3.87	0.773
11	O-PPE3	1	3	5	18	18	4.09	0.818
12	O-PPE4	3	3	11	17	11	3.67	0.733
13	O-PPE5	2	2	5	15	21	4.13	0.827
14	O-PPE6	0	1	13	17	14	3.98	0.796
15	O-PPE7	4	8	13	14	6	3.22	0.644
16	O-PPE8	6	8	7	12	12	3.36	0.671
17	O-PPE9	7	13	10	8	7	2.89	0.578
		Excavation Safety						
18	O-E1	3	7	8	17	10	3.53	0.707
19	O-E2	1	5	8	17	14	3.84	0.769
20	O-E3	0	1	10	15	19	4.16	0.831
		Ladder Safety						
21	O-L1	0	1	8	20	16	4.13	0.827
22	O-L2	0	3	17	12	13	3.78	0.756

O-SC(X) = Operational-Site Conditions(X=1-8), O-PPE(X) = Operational- Personal Protective Equipment (X=1-9), O-E(X) = Operational- Excavation(X=1-3), O-L(X) = Operational- Ladder safety(X=1-2)

Table 4: weighted average score of operational factors (continued)

				Lift Safety				
23	O-LS1	1	4	9	17	14	3.87	0.773
24	O-LS2	1	11	15	8	10	3.33	0.667
25	O-LS3	2	9	10	15	9	3.44	0.689
				Scaffold Safety				
26	O-SS1	0	11	8	14	12	3.60	0.720
27	O-SS2	1	6	7	15	16	3.87	0.773
28	O-SS3	0	3	12	12	18	4.00	0.800
29	O-SS4	0	3	10	16	16	4.00	0.800
30	O-SS5	1	5	6	21	12	3.84	0.769
31	O-SS6	3	7	9	18	8	3.47	0.693

				Safety at Heights				
32	O-SH1	0	0	0	9	36	4.80	0.960
33	O-SH2	3	5	12	14	11	3.56	0.711
34	O-SH3	1	6	6	18	14	3.84	0.769
				Safety by Housekeeping				
35	O-HK1	4	4	10	12	15	3.67	0.733
36	O-HK2	0	3	6	20	16	4.09	0.818
37	O-HK3	0	4	6	14	21	4.16	0.831
38	O-HK4	0	5	5	17	18	4.07	0.813
39	O-HK5	2	4	11	15	13	3.73	0.747
40	O-HK 6	2	4	12	15	12	3.69	0.738
41	O-HK 7	1	4	15	13	12	3.69	0.738

O -LS(X) = Operational - Lift Safety(X=1-3), O-SS(X) =Operational- Scaffold Safety (X=1-6), O-SH(X) = Operational- Safety at Heights (X=1-3), O-HK(X) = Operational- safety by House Keeping (X=1-7)

3.7.2 Field Data Results:

Project related data is referred as field data. A total of 45 projects were visited and investigated for the evaluation of safety culture and safety performance on the basis of factor scores. Results have been classified according to various natures of information regarding projects.

There were three ranges set forth for classification of projects. 13 (29%) of projects were below 500 million in contract sum, 12 (27%) were between 500 – 1000 million and 20 (44%) of them were large projects with contract sum greater than 1000 million (Fig 9). The next considered factor which casts some effect on the safety performance of a project is the experience of firm in particular type of work. The data statistics of firms' experience with experience ranges as <5, 5-10, 11-15, 16-20 and > 20, are presented in Fig (10).

Figure 9. Frequency distribution of Contract sum of projects

Figure 10. Frequency distribution of Firm experience

It was evident from the results of factors ranking that presence of qualified supervisor holds a profound impact on ensuring safety of the project. Next factor that was observed was the work-hours rule on the project. Most common work-hour duration followed was of 10-hours a day on 47% (21) of projects. Figure 11 shows that the industry is having long work-hours with higher percentage of projects keeping a rule of 10 and 12 hours a day rather than 8 hours.

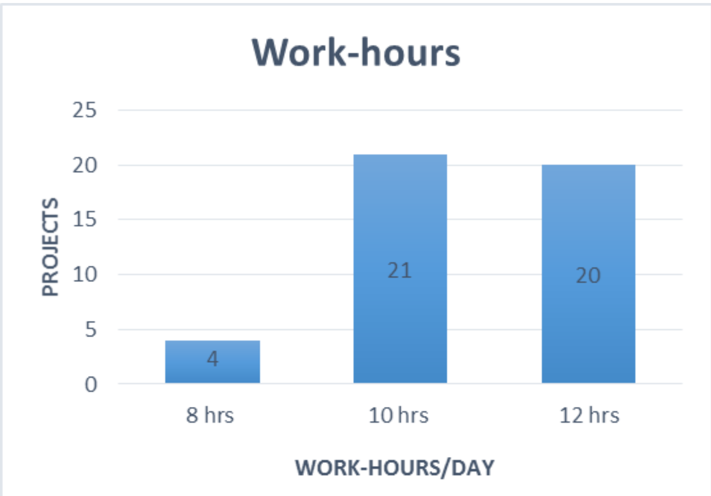

Figure 11. Frequency distribution of work-hours on projects

Figure 12 shows that 34 of the total projects' client was a private party, 11 of them were public projects and 6 were under semi-government organization as client. Figure 13 shows a general trend of number of sub-contractors hired in the project. This feature explains the number of interfaces for effective safety management of the project.

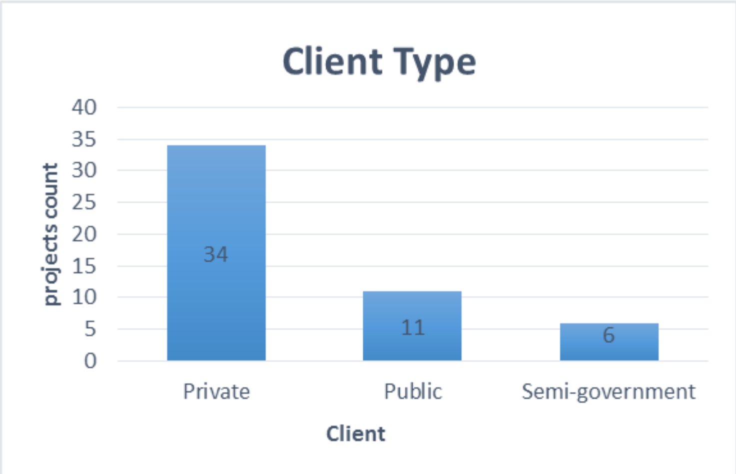

Figure 12. Frequency distribution of client type of projects

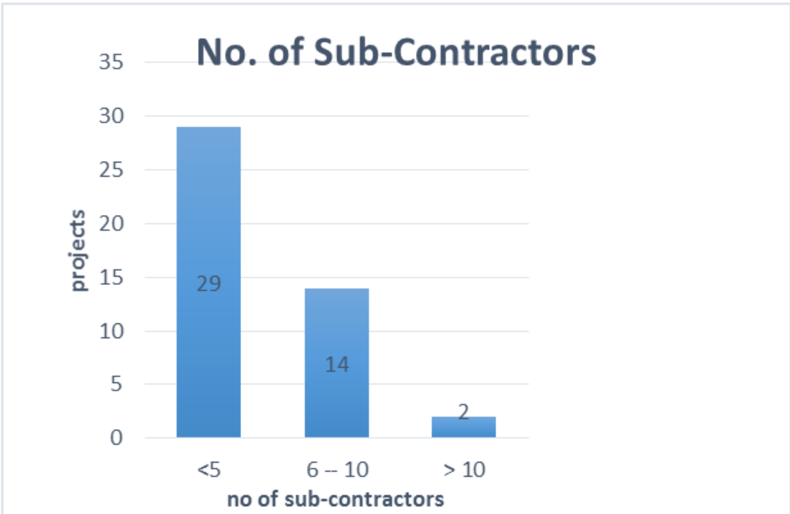

Figure 13. Frequency distribution chart of no. of sub-contractors on projects

3.7.3 Safety Performance of Projects:

Safety performance of construction projects was observed on the basis of safety measures enlisted from literature. It was estimated in the form of a score based on the product of existence value and score of each safety measure. On a whole 55.55 percent of projects showed a medium level safety performance, 31.11% of them were falling into the low performance, 8.88% of projects showed very low safety performance on the sites while only 4.44% had a remarkable safety performance with highest score of 79.5 which is still near the lower range of the category i.e., 76.

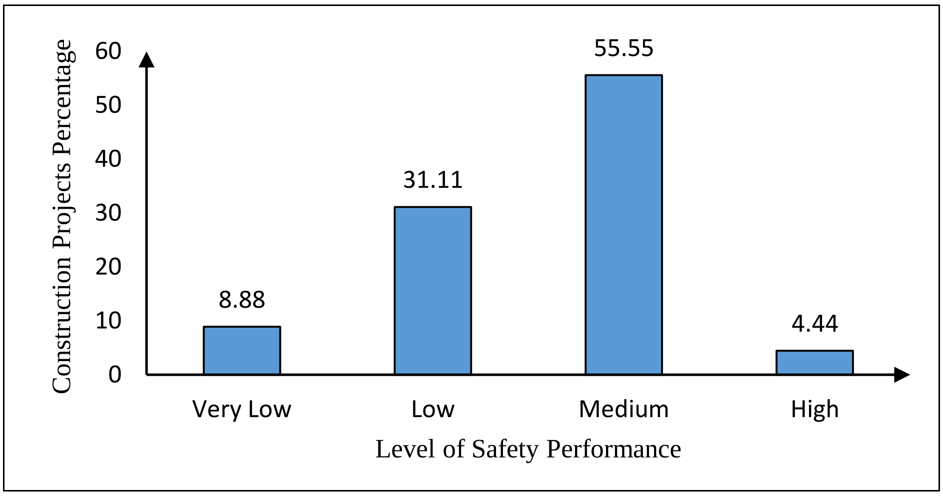

Figure 14. Percentage frequency distribution of safety performance of projects

A statistical analysis was carried out for a detailed view of safety conditions with respect to some project features variations. Figure 14 shows the trend of safety performance in form of frequency distribution of projects with respect to firm experience, project cost and client nature respectively. In case of firm experience, it was seen that as firm experience grew the percentage of projects with very low safety performance increased. In the experience years of <5, 5-10 and 11-15 there were no projects found with very low safety performance. Moreover, the highest percentage of projects with medium safety performance was under the experience years of 11-15 with 67%. This may explains that the firms with higher experience are less prone towards safety actions. Due to an already set reputation the firms face less competition in contract award. Some of the major reasons quoted by the interviewees was that the firms with more experience have a financial room towards facing safety failure costs and less competition in contract award. The frequency distribution of safety performance of projects with respect to firm experience is shown in figure 15.

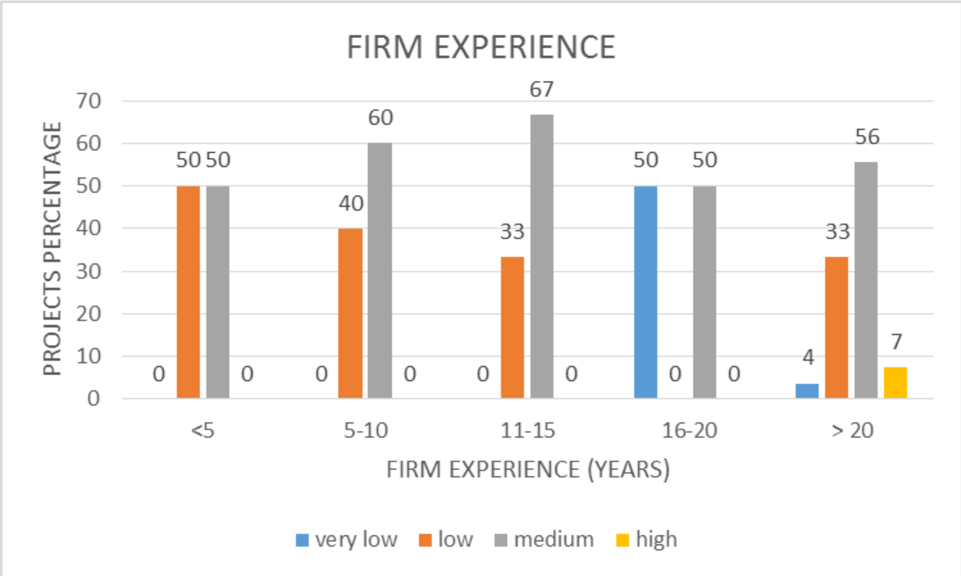

Figure 15. PFD of safety performance and firms’ experience

Figure 16 shows the frequency distribution of safety performance with respect to project cost given as contract sum. The result depicts that higher cost projects tend to follow safety measures more as high cost projects are awarded to a strong firm which has satisfactory safety policy and plan.

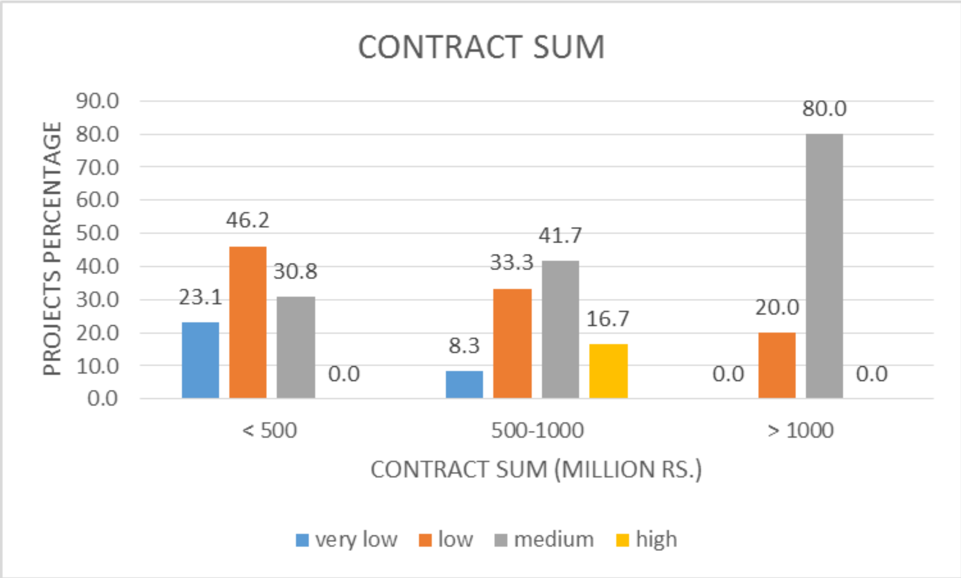

Figure 16. PFD of safety performance levels w.r.t contract sum

Figure 17 shows the no of projects with the four levels of safety performance with each client type. It is evident from the results that safety performance of public projects is not at all satisfactory. Less number of projects were available for foreign/semi-government category, only one project was found and it had medium safety performance.

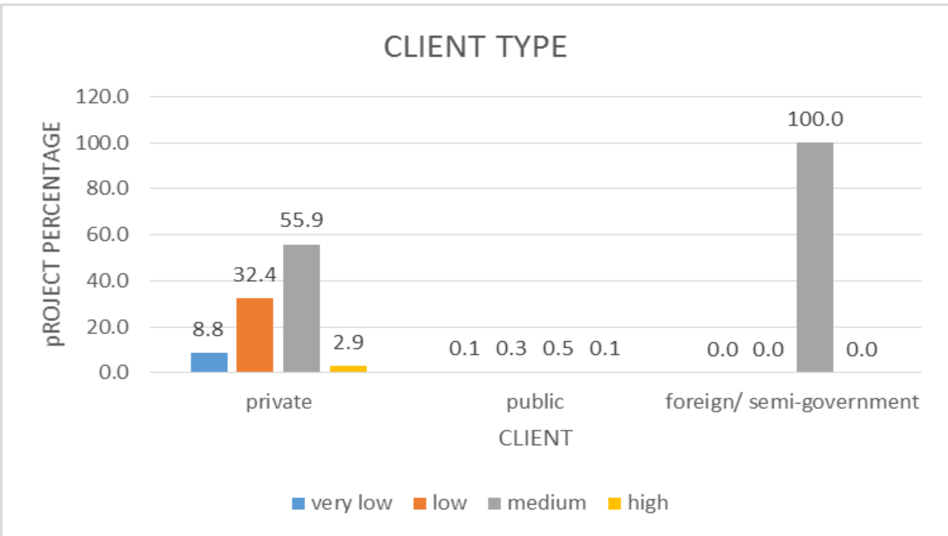

Figure 17. PFD of safety performance levels w.r.t client type

Chapter 4

ORDERED PROBIT MODEL ANALYSIS

4.1 INTRODUCTION

Studies reveal that safety performance is evaluated in lighted of both leading and lagging indicators. Lagging indicators (like accident reports, RIR and lost work-hours etc.) are considered more as a measure of failure of a management system in ensuring safety at sites (Toellner, 2001). Whereas, leading indicators (safety culture and hazard control planning) provides a proactive measure of safety performance before any fatality may occur. Hinze (2005) concluded that intervention of these leading indicators into the managerial and technical plan of project execution reduces the chance of any fatality or mishap on the site. The leading indicators, when brought into practice and frameworks, form a safety culture of organization. This safety culture may performs on various projects differently depending upon some project related features that may affect the safety performance on site. Hinze and Teizer (2011) and Mohamed (2002) conducted distinct researches that explored the effects of project related features namely; work visibility and heavy tools, and managerial aspects on construction accidents respectively. Arkson and Hadikusmo (2008) conducted a study analyzing the success factors of safety management systems in medium and large projects through descriptive statistics. The study revealed that the safety management plan or policies may differ according to project variation. Most of the studies conducted on safety performance were either based on lagging indicators or with descriptive statistics if considered leading indicators. Second most important study approach in safety is the decision making analysis considering the safety risks as data inputs. There is seen scarcity in use of probabilistic statistics.

This chapter is intended to investigate the factors that play an important role in safety performance of any organization safety culture. Based on the data collected the safety performance of projects is in categories of very low, low, medium and high. Owing to the ordinal nature of independent variable (on-site safety performance), the ordered probit approach was considered in order to investigate the significant factors that mark an influence on the safety performance (Abdel-Aty, 2003). Another motivation for selection of this approach was that it offers better results even with a small sample (Ye and Lord, 2014).The results revealed a set of most significant factors from both managerial and project features. This will help the industry in formulating best safety plan according to the project variances.

4.2 RESPONSE (Y) AND EXPLORATORY (X) VARIABLES:

Safety performance on construction sites is the response variable (Y) which is categorized into four sets; very low, low, medium and high. The data set contains 34 explanatory variables which belong to management factors and project features. The management factors are mostly in binary nature due to their existence or non-existence in the safety culture of an organization. The project features are in categorical and continuous form as well. In the data set Y is the dependent variable whose values are calculated on basis of field data collected in the form of score ranging from 0-100, further sub-divided into four categories. The explanatory variables (X_i) are the independent variables that are expected to influence the Y in a particular manner and intensity. Table 5 explains a brief description of the response and explanatory variables that were included in the data set.

Table 5: Response and Exploratory variables

Sr #	Variable Description
1	Safety performance of construction projects (0 if very low, 2 if low, 3 if medium and 4 if high)
2	Safety policy is developed by the firm (1 if exist, 0 otherwise)
3	Existence of separate safety department (1 if exist, 0 otherwise)
4	Authorities and responsibilities of safety department members are clearly written in policy (1 if exist, 0 otherwise)
5	Safety goals are set and fully clear to safety department members (1 if exist, 0 otherwise)
6	Safety performance of contractors/sub-contractors on their previous projects included in the selection criteria (1 if exist, 0 otherwise)
7	Requirement of safety policy and safety plan as compulsory document in the bid (1 if exist, 0 otherwise)
8	A worker-hour restriction in agreement (1 if exist, 0 otherwise)
9	Safety trainings and meetings held regularly (1 if exist, 0 otherwise)
10	Regular safety inspections by safety supervisor on site (1 if exist, 0 otherwise)
11	Safety is given priority in visits by the head office personnel (1 if exist, 0 otherwise)
12	Tool box meetings are held on site regularly (1 if exist, 0 otherwise)
13	Safety representative is designated with the authority to stop work if he finds any unsafe condition until prevented (1 if exist, 0 otherwise)
14	Safety resources are allocated in terms of time and cost in schedule and budget (1 if exist, 0 otherwise)
15	Provision of personal protective equipment to workers (1 if exist, 0 otherwise)
16	An effective communication channel exists between management and workers (1 if exist, 0 otherwise)
17	There is a reward or punishment system for performing safe or unsafe work (1 if exist, 0 otherwise)
18	Presence of qualified supervisors on-site (1 if exist, 0 otherwise)
19	Worker's experience involved in preparing safety management plan prior to commencement of job (1 if exist, 0 otherwise)
20	Workers' feedback is encouraged to improvise or review the safety plan (1 if exist, 0 otherwise)
21	Physical and mental examination of workers are carried out (1 if exist, 0 otherwise)
22	Drug/alcohol test is carried out from time to time or on surprise basis (1 if exist, 0 otherwise)

Table 5: Response and Exploratory variables (continued)

23	A job-hazard analysis is conducted prior to commencement, identifying all safety risks expected in that job (1 if exist, 0 otherwise)
24	Workers are encouraged to report near misses (1 if exist, 0 otherwise)
25	Accidents or near misses are investigated timely and fairly (1 if exist, 0 otherwise)
26	Installations on site; scaffolding, lift, tower crane, batching plant are not permitted to use without inspection of qualified inspectors of each (1 if exist, 0 otherwise)
27	Weekly inspection of installations (1 if exist, 0 otherwise)
28	All these installations are not permitted to use without inspection in case of exposure to a severe weather condition that could be harmful to them (1 if exist, 0 otherwise)
29	Firm Experience (<5=1, 5-10=2, 10-15=3, 15-20=4, >20=5)
30	Contract Sum (<500 million=1, 500-1000 million=2, >1000 million=3)
31	Skilled Staff (numbers)
32	Unskilled Staff (numbers)
33	Work-hours (8 hours= 1, 10 hours=2, 12 hours=3)
34	No.of Sub-contractors (continuous)
35	Duration (months)

4.3 METHODOLOGY:

This research is motivated to understand the link of safety performance of construction projects with various explanatory variables. Duncan et al. (1998) showed that unordered multinomial logit models, nested logit and probit models which account for the categorical nature of the response variable, cannot be used for interpretation of ordinal natured response variable. In the existing research, the safety performance (i.e. ordinal) of the construction projects was calculated by assigning score on a scale of 0 to 100. The performance interval was categorized on a four levels ordinal scale as very low (0-25), low (26-50), medium (51-75) and high (76-100). In the past, ordered probit model was extensively applied in case of ordinal dependent variable. The safety performance being an ordinal variable which is why an ordered probit approach was developed to investigate the relation of safety performance of construction projects and various explanatory variables. According to the generalized equation of ordered probit model a latent variable (i.e. unobserved), "*Y**" can be written as,

$$Y_i{}^{*} = \beta X_i + \varepsilon_i \tag{4.1}$$

Where Y_i= latent (i.e. continuous) variable and is a measure of safety performance of a construction project i.

X_i= $(k * 1)$ vector of observed non-random explanatory variables.

β = $(k * 1)$ vector of parameters to be estimated.

ε_i = random error term assumed to follow normal distribution (i.e. mean=0 & variance=1).

For any given construction project, it can be reasonably presumed that level of safety performance (i.e. Y_i*) can be related to the level of observed performance (i.e. Y_i) through the following equations (Ye and Lord, 2014).

$$Yi = \begin{cases} 0 \;\; if -\infty \leq Yi* \leq \mu 1 & (very\ low\ safety\ performance\ level) \\ 1 \;\; if \;\; \mu 1 < Yi* \leq \mu 2 & (low\ safety\ performance\ level) \\ 2 \;\; if \;\; \mu 2 < Yi* \leq \mu 3 & (medium\ safety\ performance\ level) \\ 3 \;\; if \;\; \mu 3 < Yi* \leq \infty & (high\ safety\ performance\ level) \end{cases} \tag{4.2}$$

Where μ_n= thresholds values to be estimated for all safety performance levels that defines *Y**. The relationship of latent (i.e. continuous) performance variable, *Y*i and the observed performance level, *Y*i. The likelihood that a construction project *i*, a safety performance level *j* is equal to the likelihood that the latent performance tendency, *Yi** will consider a value between two fixed thresholds parameters. The probability associated with each safety performance level can be written as;

$$\begin{aligned} Prob(Y=0) &= \varphi(\mu_1 - \beta X_i) \\ Prob(Y=1) &= \varphi(\mu_2 - \beta X_i) - \varphi(\mu_1 - \beta X_i) \\ Prob(Y=j) &= \varphi(\mu_J - \beta X_i) - \varphi(\mu_{j-1} - \beta X_i) \\ Prob(Y=J) &= 1 - \varphi(\mu_{j-1} - \beta X_i) \end{aligned} \qquad (4.3)$$

In the above equation 4.3, the symbol φ stands for cumulative normal distribution function. The thresholds must be *j-1* in accordance with the number of levels of safety performance that are four, Whereas, LIMDEP is unable to estimate one of the thresholds (i.e. by maximum likelihood technique) and therefore gives only two thresholds i.e., *j-2*. Greene (2000) came up with a suggestion to solve this issue by considering the first threshold (μ_1 equal to 0. The thresholds in the model should follow the ordering as given in equation 4.4, in order to have positive probabilities for each of the safety performance level as given in equation (4.3).

$$\mu_1 = 0 < \mu_2 < \cdots < \mu_{j-1} \qquad (4.4)$$

The ordered probit model only estimate the probability of the two extreme levels of the response variable which is why, marginal effects are calculated to understand the effect of unit change in any explanatory variable (i.e. $X_i\ s'$) on the probability of the intermediate categories of the response variable as;

$$\frac{Prob(Y=j)}{\partial x} = [\varphi\ (\mu_{j_1} - \beta X_i) - \varphi\ (\mu_j - \beta X_i)]\beta \qquad (j = 0,1,2,3) \qquad (4.5)$$

The above equation can be used for estimation of the marginal effects when the explanatory variable is continuous. A unit change means when there is a unit increase or decrease in the value of explanatory variable from its mean value. In case, explanatory variable is categorical (i.e. not continuous), Greene (2007) suggested equation 4.6, for estimation of marginal effects of categorical variable X_i (i.e. when Xi changes from 0 to 1 while holding all other variables at their mean values) on the corresponding probabilities of each safety performance level.

$$X_i = P(y = j|X_i = 1) - P(y = j|X_i = 0) \tag{4.6}$$

4.4 DATA:

The description of response variable and explanatory variable data type are explained in previous section. The explanatory variables of management factors are binary in nature i.e., 1 if exists and 0 otherwise. Whereas, the project related features are different in natures. Firm experience, project size in terms of cost, work-hours are ordinal with different categories. Ratio of skilled to unskilled workers and no. of sub-contractors were continuous in nature. For the response variable, data is described in Figure 3.13.

The descriptive statistics of all the explanatory variables were calculated. Table 6 shows the descriptive statistics of those variables that were significant in the model estimation. Safety policy indicator describes the factor of ‘ requirement of safety plan and policy as compulsory document in bid’, safety visits means that ‘safety audits are conducted by head office as priority on regular intervals’, T.B. Meetings indicator refers to the ‘practice of regular tool box meetings’, Qualified

Supervisor appointed on site , firm experience indicates the experience of contractor firm ,carrying out wok on site, in years, contract size indicator refers to the contract sum which may mean estimated cost of the project and the last is more skilled labor indicator for high ratio of skilled to unskilled workers on site. The descriptive statistics of these are following:

Table 6: Descriptive statistics of significant exploratory variables

Variable	***Description***	***Std.Dev***	***Mean***
Safety policy indicator	1 if requirement of safety plan and policy is present as compulsory document in bid, 0 otherwise	0.6444	0.4840
Safety visits indicator	1 if safety is given priority in visits by the head office personnel, 0 otherwise	0.6000	0.4954
T.B. Meeting indicator	1 if tool box meetings are held on site regularly, 0 otherwise	0.6666	0.4767
Qualified supervisor indicator	1 if qualified supervisors are present on site, 0 otherwise	0.7777	0.4204
High contract size indicator	1 if contract sum is greater than 1 (i.e. greater than 500 millions), 0 otherwise.	0.6888	0.4681
More skilled labors indicator	1 if ratio of skill to unskilled labors is greater than 0.29, 0 otherwise.	0.9111	0.2877

4.5 MODEL ESTIMATION RESULTS:

In the current research, an ordered probit model was estimated to scrutinize the statistically significant factors affecting the safety performance of the construction firms. During the model estimation, a hit and trial technique was tracked in order to estimate a cluster of explanatory variables with significant t-stats (i.e. at 95% level of confidence) and correct intuitions. Out of 34 various variables, 6 variables were found in statistical association with the response variable Table 6. The marginal effects of each of the 6 independent variables were assessed shown in Table 7, to understand the percent change in the safety performance, with a unit increase in the specific explanatory variable (i.e. keeping all dummy variables at zero or mean values). A positive coefficient (i.e. β) shows that the probability of high level of safety performance of construction project increases with a unit increase in a particular independent variable and vice versa.

Table 7: Estimation Results of Ordered Probit Model

Variable			***Marginal Values***			
	Coeff.	***t-stat***	***Very low***	***Low***	***Medium***	***High***
Constant	-2.506	2.959				
Safety policy in bid indicator	1.432	2.770	-0.0192	-0.5061	0.5210	0.0043
Safety visits indicator	1.436	2.868	-0.0165	-0.5109	0.5223	0.0052
Meeting indicator	1.036	2.153	-0.0103	-0.3850	0.3928	0.0026
Qualified Supervisor	1.407	2.382	-0.0286	-0.4767	0.5030	0.0024
Project size indicator	2.407	3.519	-0.0915	-0.6578	0.7409	0.0085
Skilled labors indicator	1.720	2.193	-0.0032	-0.4902	0.4477	0.0457
Threshold 1	2.843	4.199				
Threshold 2	6.126	6.522				

Note: Model summary statistics: Number of observations=45; degrees of freedom = 6; log likelihood = -24.8863; restricted log likelihood = -48.0500; adjusted McFadden's Pseudo rho-squared (ρ^2) = 0. 4820. Dependent variable safety performance particulars: High coded 3; Medium coded 2; Low coded 1 and Very low coded 0.

The estimation results showed that safety policy indicator is positively associated with the safety performance of construction of construction projects. The likelihood of the high safety performance level increases and that of the very low performance level decreases with every unit increase in (i.e. existence of safety plan and policy as compulsory document in bid). Zuo and Sunindijo (2013) also suggested this practice to be adhered to contract agreement and award procedure. The descriptive statistics of the dataset also validates this result because greater percentage of high level of safety performance and smaller percentage of very low safety performance is indicated in the projects where existence of safety policy is set as compulsory document in the bid in Figure 18.

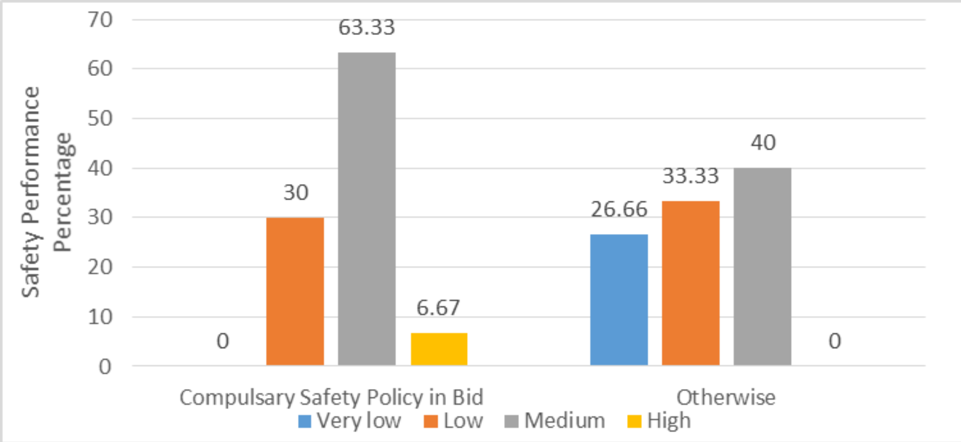

Figure 18. Safety Policy in bid evaluation Frequency Distribution

The safety visits indicator (i.e. safety given priority in visits by head officials) tends to increase the probability of high level of safety performance and decrease the probability of very low safety performance level. Hinze et al., (2013), Ismail (2012) and Vinodkumar (2011) have also emphasized on this factor.

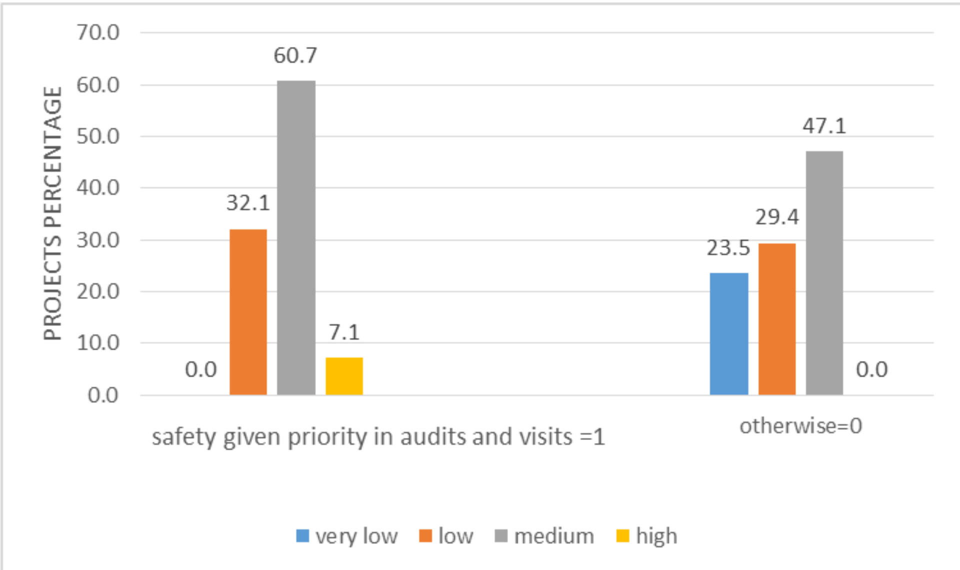

Fig. 19. “Safety Prioritized as an Objective in Visits” Frequency distribution

Likewise, the model results suggest that the probability of high level of safety performance increases if regular tool box meetings are held on site. This finding is consistent with the past literature (Liska et al. 1993, Choudhary 2007, Goh and Chua 2013).

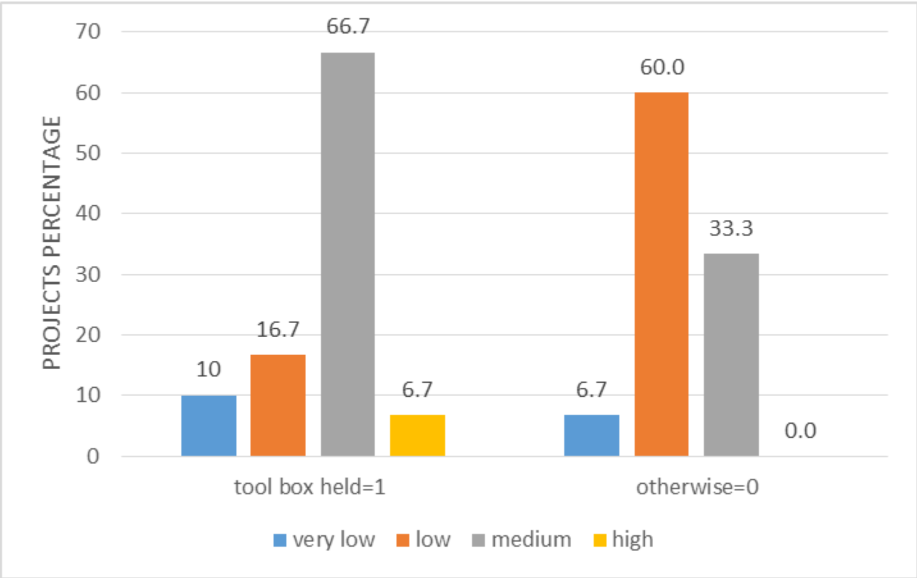

Fig. 20 Tool box meetings indicator frequency distribution

The presence of qualified supervisor on the construction site also increases the likelihood of high level of safety performance which is consistent with the past research (Sawacha et al. 1999, Huang and Hinze 2006, Rashid et al, 2007). Referring marginal effects (Table 7), unit increase in the qualified supervisor indicator (i.e. presence of qualified supervisor on site) increases the probability of high level of safety performance by 0.03% where decreases the probability of the very low level of safety performance by 0.47%.

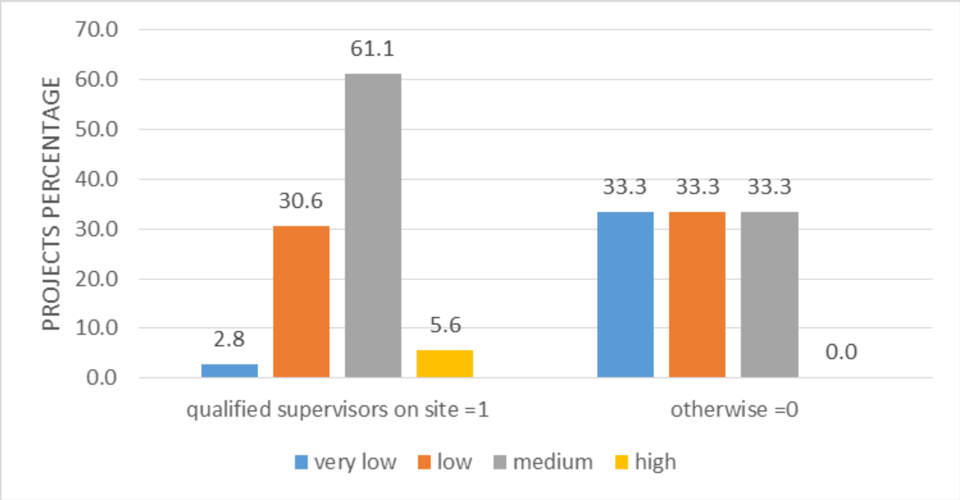

Fig. 21. Qualified Supervisors on site frequency distribution

The findings also include that likelihood of high level of safety performance increases with the contract size of the project (i.e. once it's greater than 500 million). The project size shows the reputation and integrity of the firm (i.e. mostly big projects are awarded to firms on their previous performance) which passively endorses this finding. The frequency distribution of project size (i.e. greater than 500 million) also indicated a greater percentage of high level and lower percentage of very low safety performance (Figure 22).

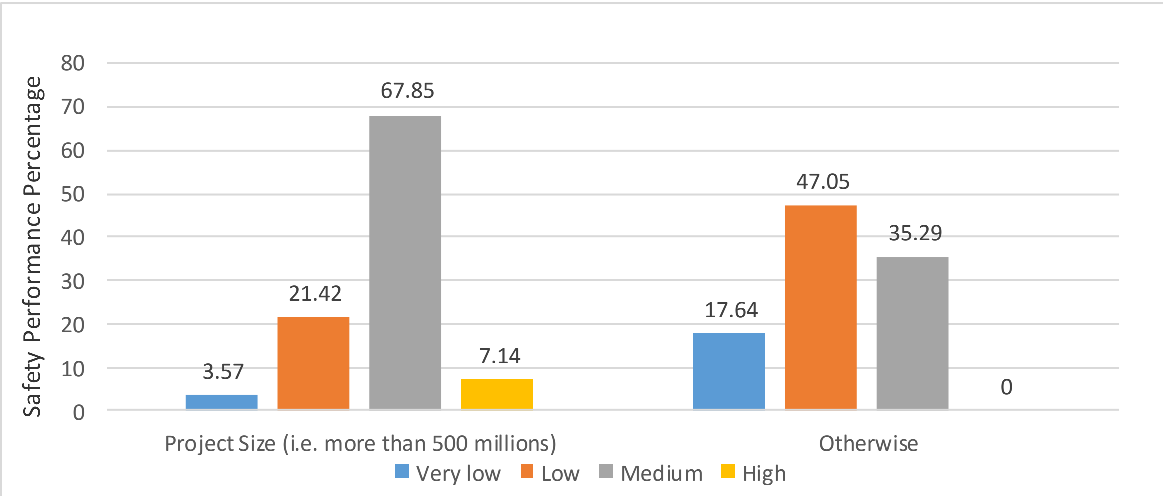

Figure 22. Frequency Distribution of Project Size and Others

Also, increase in the skilled labors as compared to unskilled labors (i.e. ratio of skilled to unskilled labors greater than 9) increases the probability of high level of safety performance in the construction industries. The result shows agreement with the findings pof some past literature also (Dempsey and Mathiassen 2006, Fin et al. 2000). The frequency distribution shows greater percentage of high level of safety performance and lower percentage of very low safety performance level as compared to others (Figure 23).

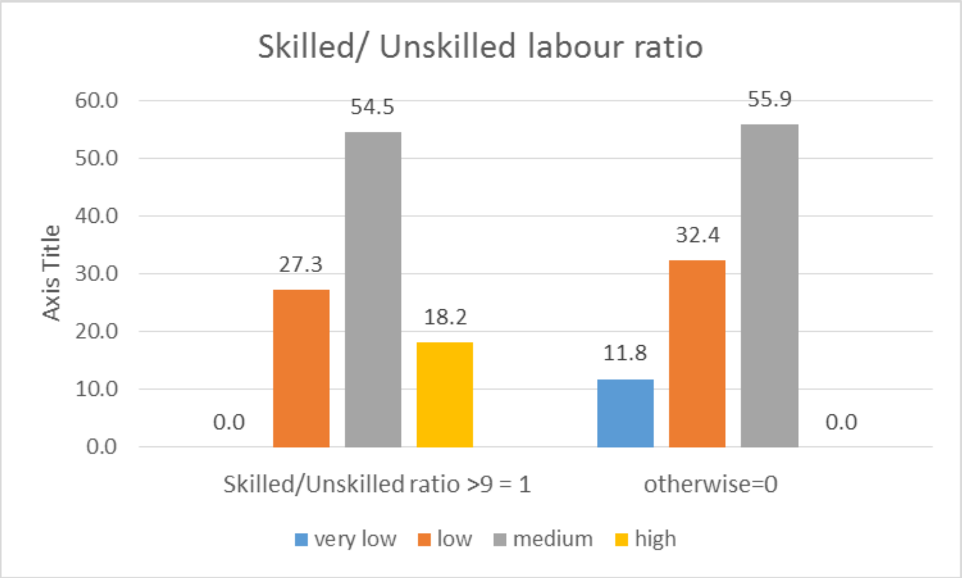

Figure 23. Frequency Distribution of skilled Labors and Others

4.6 CONCLUSIONS

The objective of this study was to understand the interrelationship of safety performance of construction projects and various factors. 7 out of 34 variables depicted a significant association with the safety performance of the construction projects (i.e. statistically significant at 95% level of confidence). The results showed that presence of safety policy as compulsory document in bid, prioritizing safety by head official during visits, holding tool box meetings and presence of qualified supervisor on site tend to increase the likelihood of the high level of safety performance of the construction projects. Likewise, the increase in contract size (i.e. greater than 500 millions) and increasing percentage of skilled labors (i.e. ratio of skilled to unskilled labors is more than 0.11) are also positively associated with the safety performance of the projects. According to the model results, as the firm experience increases (i.e. greater than 10 years) so the probability of the high level of safety performance decreases. The use of ordered probit model which will eventually help in understanding the association and impact of various contributory factors on the safety performance. The findings of this study are expected to reduce the gap in construction safety and will help in suggesting appropriate countermeasures to alleviate the issue.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The chapter concludes all the results based on both the types of data collected. As a result of online survey a brief framework is obtained for setting up a safety culture of organization with the extraction of most important factors from each category of safety managerial factors. From field data, the current situation of safety in Pakistan construction industry is observed which shows the performance of different projects varying in some basic features. Based on the model estimation results of field data, the association and impact of various safety factors from managerial and project features with the safety performance of any project is achieved.

5.2 SYNOPSIS OF STUDY AND CONCLUSIONS

The portion below gives a brief description of objectives of the research, the methodology adopted to obtain each, status of achievement and the respective chapter of explanation.

1. To identify state of the art safety practices:

To achieve this objective, at first literature review was conducted to obtain as many safety practices at management and project site level. After that through an online survey these factors were prioritized on the basis of mean score achieved by each factors. Appendix B shows the set of most important safety practices from the point of view of Pakistan based researchers and experienced practitioners.

The policy of provision of personal protective equipment to workers was rated the highest with a RII (Relative Importance Index) of 0.804, the second factor with RII 0.764 was to set a rule of permitting temporary installations' use after the inspection from a qualified inspector, authorizing the safety representative to stop unsafe work at the spot is the third most important factor with RII of 0.764, job hazard planning prior to commencement of each activity or a phase of activities came out to be the fourth most important factor with RII of 0.751. Whereas, the setting safety goals and objectives prior to commencement of project, involvement of workers' experience in preparation of safety plans, workers' physical and mental examination on regular basis and acquiring workers' feedback in reviews of safety plans were the four lowest in importance level with RII values as 0.622, 0.618, 0.609 and 0.578 respectively.

2. To evaluate the current situation of safety in Pakistan construction industry:

To conduct the evaluation of industry's safety condition in the way of safety advancement, field data was collected. A thorough survey was done through interviews of management personnel for inquiring safety practices being followed at organization level. Projects sites were physically observed to investigate the on-site safety practices being followed in the industry so far.

The results showed that 55% of projects showed a medium level safety performance, 31.11% of them were falling into the low performance, 8.88% of projects showed very low safety performance on the sites while only 4.44% had a remarkable safety performance with highest score of 79.5 which is still near the lower range of the category i.e., 76. So it can be concluded that the Pakistan construction industry is lacking a satisfactory safety advancement.

3. To study the impact of safety managerial factors and project features on the safety performance:

A detailed survey was done by conducting interviews of 45 different projects' officials (i.e. technical and managerial). Data were collected from the projects of varying size and scope in the three major cities of the country which contained 34 various independent variables in form of managerial safety measures and the project features. Ordered probit model estimated the 7 significant impacting variables. The factors which implied a positive significance on safety performance are inclusion of safety plan and policy as compulsory bid document, prioritizing safety in head office visits, holding tool box meetings on site and appointment of qualified supervisors on the site among the 27 management factors. From the list project features project cost and skilled to unskilled labor ratio show a positive relation with the safety performance while firm experience showed a negative association with the safety performance of projects.

5.3 RECOMMENDATIONS:

The study suggests that the major reasons for the non-satisfactory safety performance of the industry are, absence of a safety regulatory authority, safety performance not included in bid evaluation of firms, clients' lack of interest in paying safety related costs, lack of safety trainings and qualifications for workers. Therefore, it is necessary to set up a safety regulatory authority that conducts safety inspections of projects and set up a framework for contracting practices with inclusion of safety ensuring practices.

5.4 LIMITATIONS:

One of the limitations of the study is the small sample size. The future studies may consider large sample space considering the construction projects in other regions of the country especially those in small cities and remote areas. Future researches may be carried out to identify the variation between the best safety practices according to research and other countries and the current safety situation of industry.

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APPENDIX A

EVALUATION OF SAFETY PRACTICES OF PAKISTAN - CONSTRUCTION INDUSTRY- ONLINE QUESTIONNAIRE

I am conducting a study to evaluate the current safety performance of Pakistan construction industry. A list of safety factors are selected that constitute a safety framework for medium to large construction projects. For the evaluation of construction safety of projects, ranking will be done according to the safety factors. For this purpose it is required to first rank these factors according to their importance and effects laid on the overall construction safety.

Kindly rank the factors in accordance of the importance scale of 1-5

1= very low, 2= low, 3= moderate, 4= high, 5=extremely high

A) PERSONAL INFORMATION

1. Name *

   ____

2. Designation *

   ____

3. Experience in construction field / academia (years)

   Mark only one oval.

   O < 5 O 5-10 O 10-15

   O 15-20 O > 20

B) SAFETY KNOWLEDGE/AWARENESS

(low = just aware of safety practices but no practicing experience regarding safety medium = moderate practicing experience in field

high = researcher / certified / high experience in practicing safety none = if never practiced and had any safety education)

4. Rate your knowledge awareness or experience according to above guidelines:

   - [ ] Low

- ☐ Medium
- ☐ High
- ☐ None

C) MANAGERIAL FACTORS:

Sr #	**DESCRIPTION**	**SCORE**
	MANAGEMENT COMMITMENT	
1	Development of safety policy	1 2 3 4 5
2	Development of a separate safety department	1 2 3 4 5
3	Clear safety roles and responsibilities of each employee	1 2 3 4 5
4	Safety goals and objectives set	1 2 3 4 5
5	Safety performance is included in selection criteria	1 2 3 4 5
6	Safety plans and policy required as compulsory bid documents	1 2 3 4 5
7	Work-hour restriction in agreement	1 2 3 4 5
	SAFETY ENFORCEMENT	
8	Safety trainings of workers and management	1 2 3 4 5
9	Safety inspections and audits conducted time to time	1 2 3 4 5
10	Safety is considered as priority in head office visits	1 2 3 4 5
11	Daily tool box meeting are held on site	1 2 3 4 5
12	Safety officer authorized to stop unsafe work	1 2 3 4 5
13	Safety resource allocation; in time, bugdet and human resouces	1 2 3 4 5
14	PPE policy for provision and enforcement of its use	1 2 3 4 5
	SAFETY CLIMATE	
15	Effective communication channel exists in organization from top to bottom	1 2 3 4 5

MANAGERIAL FACTORS (continued)

16	Reward/punishment system	1	2	3	4	5
17	Qualified supervisors on site	1	2	3	4	5
	SAFETY REVIEW					
18	Periodic safety plan review for improvements	1	2	3	4	5
19	Workers' experience & feedback in safety plan	1	2	3	4	5
20	Physical & mental examination of workers	1	2	3	4	5
21	Drug-test policy)	1	2	3	4	5
	HAZARD MANAGEMENT					
22	Job hazard analysis prior to commencement	1	2	3	4	5
23	Reporting near misses	1	2	3	4	5
24	Fair & timely accident investigation and report	1	2	3	4	5
25	Temporary installations' use permit by inspection	1	2	3	4	5
26	Temporary installations' weekly inspections	1	2	3	4	5
27	Temporary Istallations' inspection upon sever weather exposure	1	2	3	4	5

D) OPERATIONAL FACTORS

SR #	**DESCRIPTION**	**SCORE**				
	SITE CONDITIONS					
28	(On-site first aid facility)	1	2	3	4	5
29	(Contacts/Communication channel display on site)	1	2	3	4	5
30	(drinking water)	1	2	3	4	5
31	(rest shelter)	1	2	3	4	5

OPERATIONAL FACTORS (continued)

32	(food platform at or near site)	1	2	3	4	5
33	(sanitation)	1	2	3	4	5
34	(smoking prohibition on site)	1	2	3	4	5
35	(safety signage and policy display on site)	1	2	3	4	5
	PERSONAL PROTECTIVE EQUIPMENT					
36	(head protection)	1	2	3	4	5
37	(hand protection)	1	2	3	4	5
38	(Foot protection)	1	2	3	4	5
39	(High visibility jackets)	1	2	3	4	5
40	(Fall protection system)	1	2	3	4	5
41	(Eye protection)	1	2	3	4	5
42	(Protective Clothing)	1	2	3	4	5
43	(Hearing Protection)	1	2	3	4	5
44	(Respiratory Protection)	1	2	3	4	5
	EXCAVATION SAFETY					
45	(Shoring use designed by engineer/qualified person)	1	2	3	4	5
46	(Excavation warning signsto inform visitors/ workers)	1	2	3	4	5
47	(Guard rails around the excavation)	1	2	3	4	5
	LADDER SAFETY					
48	(Ladder design based on standard measures)	1	2	3	4	5
49	(Ladders mounted on proper foundation)	1	2	3	4	5
	LIFT SAFETY					
50	(Regular lift inspection and repairs)	1	2	3	4	5

51	(Lift area secured from unauthorized access)	1	2	3	4	5
52	(Lifting capacities enforcement)	1	2	3	4	5
	SCAFFOLD SAFETY					
53	(Scaffold on stable foundation)	1	2	3	4	5
54	(Safe access to scaffold)	1	2	3	4	5
55	(Safe work platform on scaffolding)	1	2	3	4	5
56	(Guard rails and toe-boards around work platform)	1	2	3	4	5
57	(Screening nets around scaffold exterior)	1	2	3	4	5
58	(Weight capacities of tools, materials and worker strictly followed)	1	2	3	4	5
	SAFETY AT HEIGHTS					
59	(Mandatory use of full body harness when at heights)	1	2	3	4	5
60	(Openings of structure and at ground covered)	1	2	3	4	5
61	(Safety nets and guard rails for openings at height)	1	2	3	4	5
	SAFETY BY HOUSEKEEPING					
62	(Toxic substances at 1.5 m from work area and electricity)	1	2	3	4	5
63	(Electric wires and installations mounted on insulators)	1	2	3	4	5
64	(Electric supply and distribution boards secured properly)	1	2	3	4	5
65	(Clear and Clean walk ways on site)	1	2	3	4	5
66	(Fire extinguishers on site)	1	2	3	4	5
67	(Material wastage and debris disposed of from site)	1	2	3	4	5
68	(Excavated loose material dumped at least 2m away from excavation edges	1	2	3	4	5

APPENDIX B

SAFETY PERFORMANCE EVALUATION- FIELD DATA QUESTIONNAIRE

A) GENERAL INFORMATION:

Entity:

- ☐ contractor
- ☐ sub-contractor

Safety Knowledge / awareness:

- ☐ Low
- ☐ Medium
- ☐ High
- ☐ None

B) PROJECT FACTORS:

1. Firm Size:

- No. of employees: ____________________
- No. of skilled workers: ____________________
- No. of unskilled workers: ____________________

2. Experience of firm:

a) Less than 5 years b) 5-10 Years c) 10-15 years d) 15-20 years

e) More than 20 years

3. Contract Sum:

a) Less than 500 million b) 500 – 1000 million c) >1000 million

4. Nature of Project: ___________________

5. No. of Sub-contractors: ___________________

6. Type of contract: ___________________

7. Location: ___________________

8. Work-hours (hours/week): ____________________

9. Type of owner:

- ☐ Public
- ☐ private
- ☐ other: ________________

10. Project duration: _________________

C) ON-SITE SAFETY PRACTICES EXISTENCE CHECK:

SITE CONDITIONS

- ☐ (On-site first aid facility)
- ☐ (Contacts/Communication channel display on site)
- ☐ (drinking water)
- ☐ (rest shelter)
- ☐ (food platform at or near site)
- ☐ (sanitation)
- ☐ (smoking prohibition on site)
- ☐ (safety signage and policy display on site)

PERSONAL PROTECTIVE EQUIPMENT

- ☐ (head protection)
- ☐ (hand protection)
- ☐ (Foot protection)
- ☐ (High visibility jackets)
- ☐ (Fall protection system)
- ☐ (Eye protection)
- ☐ (Protective Clothing)
- ☐ (Hearing Protection)
- ☐ (Respiratory Protection)

EXCAVATION SAFETY

- ☐ (Shoring use designed by engineer/qualified person)
- ☐ (Excavation warning signsto inform visitors/ workers)
- ☐ (Guard rails around the excavation)

LADDER SAFETY

- ☐ (Ladder design based on standard measures)
- ☐ (Ladders mounted on proper foundation)

LIFT SAFETY

- ☐ (Regular lift inspection and repairs)
- ☐ (Lift area secured from unauthorized access)
- ☐ (Lifting capacities enforcement)

SCAFFOLD SAFETY

- ☐ (Scaffold on stable foundation)
- ☐ (Safe access to scaffold)
- ☐ (Safe work platform on scaffolding)
- ☐ (Guard rails and toe-boards around work platform)
- ☐ (Screening nets around scaffold exterior)
- ☐ (Weight capacities of tools, materials and worker strictly followed)

SAFETY AT HEIGHTS

- ☐ (Mandatory use of full body harness when at heights)
- ☐ (Openings of structure and at ground covered)
- ☐ (Safety nets and guard rails for openings at height)

SAFETY BY HOUSEKEEPING

- ☐ (Toxic substances at 1.5 m from work area and electricity)
- ☐ (Electric wires and installations mounted on insulators)
- ☐ (Electric supply and distribution boards secured properly)
- ☐ (Clear and Clean walk ways on site)
- ☐ (Fire extinguishers on site)
- ☐ (Material wastage and debris disposed of from site)
- ☐ (Excavated loose material dumped at least 2m away from excavation edges