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A research framework for investigating the relationship between safety climate and safety performance in the construction of multi-storey buildings in Pakistan

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Abstract

Construction industry is contributing 2.39% to the GDP of Pakistan and is employing over four million people; however it is the second most injury prone industry, where employees often have to work under extreme weather conditions without taking precautionary measures. Construction of multi-storey buildings is at increase in the major cities where large and medium sized companies are working as main and sub-contractors; however these projects are suffering from fatal accidents, as safety measures are not rigorously enforced. This paper therefore presents a research framework to identify the safety climate factors which can significantly enhance the safety performance in the construction of multi-storey buildings. The quantitative data, split into calibration and validation sample, are being analyzed using exploratory and confirmatory factor analysis by examining the causal relationship between the safety climate and safety performance. Structured interviews and Delphi survey are being conducted to identify and prioritize; the causes of accidents, the impediments in the safety implementation, and the strategies to enhance the safety performance. The qualitative findings about neglected safety aspects are also discussed. Proposed safety climate measurement model would be useful to measure, monitor and improve the safety performance of construction companies in the developing countries.

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1. Introduction

The growth in the construction industry evidently reflects the level of economic development but its higher injury and fatality rate is quite alarming. The construction industry of Pakistan is employing 7.4% of total labour force but its accident rate is 15.2% (Fig. 1). Percentage of injuries in the construction industry is exceptionally higher than percentage of its employed persons, once compared with other industries (Fig. 1). Moreover, percentage of injuries has accelerated from 14.55% in 2006 to 15.2% in 2012 (Fig. 2). Thus, the construction industry has turned out to be the second most injury prone industry after agriculture, whereas its employment rate is fifth among other industries. Majority of accidents are caused by *fall from height*, and causes of these accidents include; inadequate availability and training of fall protection system, and non-availability of suitable anchorage system [1].

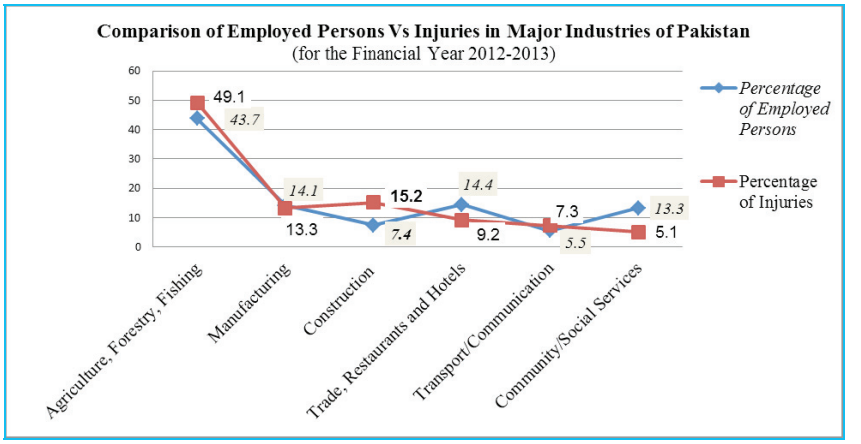
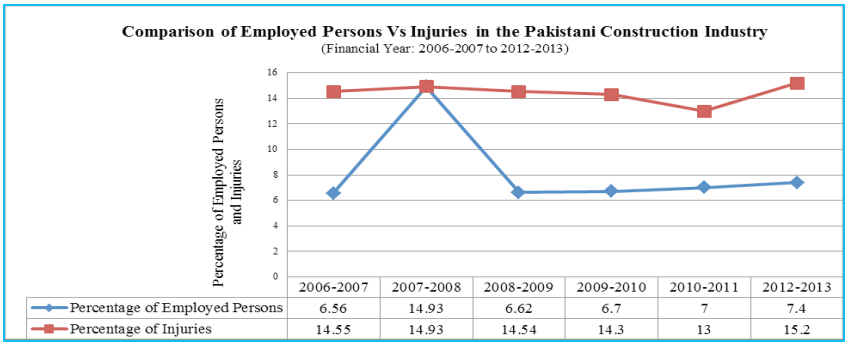


Fig. 1. Employed persons Vs injuries in major industries of Pakistan [2]



	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2012-2013
Percentage of Employed Persons	6.56	14.93	6.62	6.7	7	7.4
Percentage of Injuries	14.55	14.93	14.54	14.3	13	15.2

Fig. 2. Percentage of employed persons Vs injuries in the Pakistani construction industry
(Source: Pakistan Bureau of Statistics - Labour Force Statistics [2, 3]

1.1. Safety compliance

Construction safety has not been given much attention in Pakistan resulting in a higher accident rate. Stakeholders' emphasis is inclined only towards improving the quality, and reducing the cost and time [4]. Most of the small and medium sized constructors consider safety as a liability [5]. Workers also consider health and safety as

a limitation to their efficiency [6, 7]. No safety initiatives have been implemented by the Government [1]. Though Pakistan Engineering Council has incorporated safety clauses in its contract documents, they are not conforming to the latest technological advancement [8, 9]. According to the Labour Force Statistics, every year 4.0% of the construction employees report some sort of occupational injuries resulting into loss of working time [2, p.33].

1.2. Construction of multi-storey buildings

Currently, there are forty one under-construction multi-storey building projects (at-least 56 meters high) in major cities [10]. Realizing the adverse effects of the accidents on the overall performance, profit margin and reputation; large construction companies working on these mega projects have now started focusing on safety and are following their own safety management systems. However despite following safety standards, these projects are still suffering from fatal accidents, mainly due to fall from height and electrocution [5, 11]. Leading cause of accidents in the construction of multi-storey buildings i.e. *fall from height* [5, 11], is the major contributors to the development of current research rationale, with the aim to identify the significant safety climate factors which can enhance the safety performance on these national level building projects.

2. Problem statement

The construction industry of Pakistan is contributing 2.39% to the national GDP [12] and a large number of country's workforce (*4.424 million)* is directly engaged in this industry [2]. Unsafe conditions exist on work sites and labourers are exposed to numerous hazards and extreme weather conditions [5, 13]. Unsafe behaviours are the major causes of accidents, whereas the types of accidents include; *fall from height*, followed by lifting activity and electrocution [5, 14]. No concrete measures have been taken either by the Government or by the Pakistan Engineering Council (PEC), despite a consistent increase in the number of injuries as shown in Fig. 2 [2, 3].

However, large construction companies are following the safety regulations and implementing their safety management systems but their accidents rate is still increasing [5, 15]. Hence, there is a need to explore the current safety practices and safety management system of large construction companies, so as to identify the weaknesses in their existing system and develop future safety guidelines. Accident statistics (lagging indicator) are not available/reliable to measure the safety performance, hence it creates a space for using the leading indicator of safety climate [16] to measure the safety performance, as safety climate is a strong predictor of safety performance [17]. Likewise, there is no universal set of safety climate factors, which may be applicable to various industries, cultures and regions [18]. These inconsistencies across safety climate dimensions/constructs are due to the fact that researchers have used different questionnaires, samples and methodologies [19]. Bahari and Clarke [20] and Zhou et al. [21] have also reported that safety climate factors cannot be exactly replicated in different cultural set ups. Hence, there is a need to develop safety climate questionnaire for the Pakistani construction industry, considering the regional and cultural values.

This study is therefore focused on examining the current safety practices, identifying the contributory factors of accident causation and difficulties in the effective safety implementation. Safety climate factors will be identified using the questionnaire survey and a causal model will be developed to find the relationship between the factors of safety climate and the safety performance. Finally, strategies will be recommended to enhance the safety performance in the construction of multi-storey buildings.

3. Research aim and objectives

The study aims at investigating the relationship between the safety climate and safety performance in the construction of multi-storey buildings in Pakistan. Specific objectives are tabulated in the next section along with their respective research methods and analytical techniques.

4. Research framework of the study

Pragmatism is the underpinning philosophical worldview of the current study whereas sequential mixed methods

research design is adopted, comprising of both qualitative and quantitative methods to enhance the data validity and reliability [22]. Interview results are selected to supplement the findings obtained through quantitative data analysis. The study is started with a comprehensive literature review of safety climate, safety performance and the current safety practices in the construction of multi-storey buildings in Pakistan. Research methods and analytical techniques selected to achieve each objective are summarized in Table 1.

Table 1. Research methods to achieve each objective of the study

Research objectives	Research methods and analytical techniques
1. Examine the current safety practices in the construction of multi-storey buildings	1. Literature review 2. Semi-structured interviews 3. Field visits
2. Identify the contributory factors of accident causation & difficulties in implementing good safety practices	1. Literature review and structured interviews 2. Two rounds Delphi survey using RII
3. Determine and cross-validate the structural factors of safety climate which can significantly enhance the safety performance	1. Literature review 2. Questionnaire survey for safety climate 3. EFA and CFA for calibration and validation samples respectively
4. Examine the effect of demographic variables on safety climate	1. Analysis of Variance (ANOVA)
5. Examine the causal relationship among various safety climate factors and safety performance factors using SEM	1. CFA using PLS-SEM for model testing
6. Identify and recommend the strategies to enhance safety performance in the construction of multi-storey buildings	1. Literature review and structured interviews 2. Two rounds online Delphi survey using RII

Note: PLS-SEM=Partial Least Squares-Structural Equation Modeling, EFA=Exploratory Factor Analysis, CFA=Confirmatory Factor Analysis, RII=Relative Importance Index.

4.1. Interviews

After completing a comprehensive literature review, site visits and semi-structured interviews were conducted to know the current safety practices being followed in the construction of multi-storey buildings (Objective 1). Eight industry experts having rich working experience were targeted for the face-to-face interviews in August 2014. Each interview lasted for approximately an hour. Interviews were tape-recorded and transcribed for coding using grounded theory. Five of the interviewees belong to large construction companies whereas three of them represent small and medium sized construction companies working as subcontractors.

4.2. Delphi survey

Delphi is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem [23, p.3]. Rather than simply using questionnaire survey, the Delphi method has proven to be an appropriate method of item prioritization [24]. A two-round Delphi exercise minimizes the fatigue and attrition of experts than the repeated rounds [25, 26]. Hence, a questionnaire is prepared to conduct the Delphi survey for achieving the objectives 2 and 6. First round will be conducted during the face-to-face interview. In the second round, results will be presented to the interviewees through email to freely adjust and refine their answers in the second round. Twenty experts, representing the key stakeholders' organizations including clients, consultants, contractors, subcontractors and safety officials, will be invited to join the expert panel [25, 27]. Data will then be analysed using three tests including Kendall's coefficient of concordance (W), Spearman's rho correlation, and the Kruskal-Wallis test.

5. Qualitative research findings

5.1. Neglected safety practices on building projects

Construction safety is a new concept in Pakistan; however academia is continuously striving to generate safety awareness among the key stakeholders. Based on the literature review, site visits and semi-structured interviews; the

neglected safety aspects on construction sites are summarised as under:

- *Accident statistics.* Injury/fatality statistics of construction projects are not maintained at industry or government level, so these statistics (lagging indicators) cannot be used to benchmark the performance of construction companies [28, 29].
- *Safety manual and safety policy.* Except the large construction companies most of the small and medium sized companies do not regularly update their safety manual [30, 31]. Safety policies are made for documentation purpose only and are not rigorously enforced on sites [32].
- *Safety training and safety budget.* Safety training has been identified as the most neglected aspect, due to the safety unawareness and budget constraints [33, 34].
- *Diverse perspective of stakeholders and ineffective communication.* Managers, supervisors and the workforce have different opinion about the safety situation on work sites and it has been confirmed by Masood et al. [35] that as per managers every accident/near miss is reported but workers differ to the opinion of managers. Hence, serious communication gap is observed between the higher management and the workers.
- *Productivity Vs Safety.* Productivity is the prime concern whereas safety is not the priority of the key construction stakeholders [1]. There is a misconception that investing in safety might reduce the profit margin.

5.2. Major causes of accidents on building projects

Safety non-compliance is attributed to the absence of; workers cooperation and behaviour, familiarity with safety management techniques, safety awareness, clients' commitment, and safety regulations [36]. Researchers have highlighted the most neglected safety practices on construction sites as; poor quality scaffolding without guard rails, defective ladders not tied properly, working on roof without edge protection, temporary laid power lines and manual deep excavation without bracing [37, 38]. Major causes of injuries on building projects, in descending order, are; fall from height, electrocution, caught in between the machinery and struck by falling objects [39]. Higher unemployment ratio, more number of unskilled workers, co-workers pressure, and job insecurity are also the underlying causes of accidents [40]. Major reasons for safety non-adherence are concluded as; greed for making profit, delusion that investing on safety increases the project budget, non-existence of a regulatory authority, workers' ignorance, poor management, political influence, meeting deadlines, no safety training, and shortage of safety personnel [41-45].

6. Quantitative research methodology

6.1. Research hypothesis (H_0)

Safety climate can effectively predict the future safety performance [17, 46] and it can be accurately measured using the lagging indicators of accident statistics but due to their non-availability, leading indicators are used in this research. Three most common constructs of safety performance have been used, namely; self-reported injuries and near misses, safety participation and safety compliance. The more positive the safety climate, the higher levels of safety participation is expected. Likewise, higher level of safety climate may imply better safety management, safety knowledge and awareness of safety within the company, resulting into better compliance with safety rules and regulations. Similarly, workers are less likely to engage in unsafe actions resulting into a decrease in the self-reported injuries and near misses. Hence, following hypotheses are made for this study:

- H_1: Safety climate is negatively correlated with self-reported injuries and near misses.
- H_2: Safety climate is positively correlated with safety participation.
- H_3: Safety climate is positively correlated with safety compliance.
- H_4: Safety climate can effectively predict the safety performance.

6.2. Questionnaire design

Survey questionnaire, being an effective instrument to gauge the people's perceptions, is used for achieving objectives 3 to 5. Though safety climate has been used by numerous researchers to study its effects on safety performance, consensus on its factors could not be achieved yet [16, 47]. Moreover, safety climate factors cannot be exactly replicated in different cultural set ups [21]. Therefore, safety climate questionnaire developed by the Hong Kong construction industry and validated by Hone et al. [15] is selected for this study after incorporating the necessary changes, based on the national cultural values, and the pilot study.

6.3. Descriptive statistics

Demographic variables will be analysed as independent variables using the analysis of variance (ANOVA) to study their influence on the dependent variable of safety climate for different working groups and stakeholders. Data reliability will be checked using Cronbach's alpha [48].

6.4. Determining safety climate factors using exploratory and confirmatory factor analysis

The quantitative data will be split into two halves randomly to make calibration and validation sample. Exploratory factor analysis (EFA) will be conducted using SPSS for identifying the most significant safety climate factors [49]. Bartlett test of sphericity will be conducted to check the statistical probability that the correlation matrix has significant correlations among at least some of the variables. Measure of sampling adequacy using Kaiser-Meyer-Olkin (KMO) measure will be conducted to check the appropriateness of sample for applying factor analysis [50]. Number of factors to be extracted or deleted will be measured using scree plot and eigenvalues greater than 1. Factor structure will also be rotated for better interpretation. Pallant [51] recommends to begin with direct oblimin and then check the degree of correlation between the factors. Tabachnick and Fidell [52] suggest that oblique rotation should be selected if factor correlations exceed 0.32. Hence, for this study direct oblimin will be used as a method of rotation. The factor structure obtained through EFA will be validated using partial least squares method of structural equation modeling (PLS-SEM) on the validation sample. Factor structure will also be compared with the results of previous researches [15, 53] to identify the differences observed in a different culture and region.

6.5. Causal relationship between safety climate and safety performance using SEM

SEM is selected to achieve the objective 5 of finding the causal relationship between safety climate factors and the measures of safety performance. SEM is primarily used to examine the relationship of one or more independent variables (IVs) with one or more dependent variables (DVs). Both IVs and DVs can be either measured variables (directly observed) or latent variables (unobserved) [54]. SEM is unique from other multivariate techniques as it can take into account latent variables, and can provide explicit estimates of error variance parameters [55]. PLS-SEM is selected for this study because of its effectiveness in exploring key driving constructs, theory testing, theory development, its capability of dealing with non-normality data sets, and its minimum demand for a sample size [55]. The analysis of the causal relationship will help to explore the effects of safety climate factors on safety performance in the construction of multi-storey buildings.

7. Significance and value

Safety climate research has attracted much attention in the developed countries; however, not much has been done in Pakistan. Researches on dimensions of safety climate have suggested that safety climate structure may be industry-specific and region-specific so this study will determine the specific dimensions of safety climate for the Pakistani construction industry. Development of an industry-specific causal model may assist the construction professionals to measure, monitor and improve the safety performance of their companies. Comparison of results with similar studies in Hong Kong and other countries will help to identify the differences of safety climate constructs and their respective significance. According to the report of Census and Statistics Department [56, p.78],

18.9% of ethnic minority construction workers in Hong Kong belong to Pakistan (second highest after Nepalese), so this study may shed light to better understand their safety attitude and behavior. Besides cross-validating the safety climate questionnaire of the Hong Kong construction industry, this study will strengthen the existing knowledge and reveal the deviations in the dimensions of safety climate. The study would also suggest the strategies for providing a safe work environment to the millions of construction workers in Pakistan.

8. Conclusion

This paper presents a research framework to investigate the relationship between the safety climate and safety performance on building projects. All the under-construction multi-storey building projects in major cities of Pakistan are selected for the data collection. These projects are suffering from fatal accidents mainly due to fall from height. Delphi method is adopted to ascertain; the causes of accidents, the impediments in safety implementation, and the strategies to enhance the safety performance. Calibration and validation samples are being used for conducting exploratory and confirmatory factor analysis respectively, to find the safety climate factors. Partial least squares structural equation modelling is being used to explore the causal relationship and develop a model of safety climate and safety performance. Besides cross-validating the safety climate structure of the Hong Kong construction industry in an entirely different culture and region, the proposed methodology may help the construction stakeholders in the developing countries to monitor and enhance their safety performance.

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