

## **Relating Construction Safety Performance Lagging and Leading Indicators**

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### **Abstract**

Injury/fatality rates in construction have been increased in last decade and mostly unreported due to lack of legislative body for administration of occupational health and safety in economic sectors. There is major difference found in types of construction accidents investigated in previous research studies and national statistics. Highlighted types are tool accidents; fall from height; struck by material; heat strokes; head and eye injuries which are mainly caused by defective equipments with low maintenance operated by operatives with less knowledge. Recording accidents including injuries and fatalities with proper investigation on construction sites is a lagging indicator used by contractors to measure their safety performance in specific period of time fortnightly, monthly, quarterly, biannually and annually. These statistics are used in project reports to head office and even clients. Few construction firms analyze the cost of accidents and incorporate in site overheads. Contrary, safety climate is mostly adopted leading indicator which is a measure of psychological construct of safety culture defined as product, manifestation, indicator, abstraction; snapshot and temperature of safety on construction site. A safety climate questionnaire survey (based on likert scale 1 ~ 5) was conducted on twenty three construction sites of diversified types as infrastructure, high rise buildings, facility buildings, roads and bridges. 76% of response have been received from sixty one workers of different trades (for work, steel fixing, concreting, plaster, scaffolding and related helpers). Results showed mean score of safety climate statements (related to construction hazardous, incidents and accidents) revealed as investigations are mainly used to identify who is to blame (3.61); my supervisor/safety manager welcomes reporting safety hazards/incidents (3.70); in our work environment working with defective equipment is not allowed under any circumstances (3.61); and accidents which happen here are always reported (3.82). Responsibility of accidents is not taken by either management or workers but role of supervisors is also critical which relate safety issues with self-performance. Productivity has given priority on safety due to tight schedules on construction projects which urge managers and supervisors to ignore hazardous conditions. Major reason of accident is defective equipment endorsed in psychological perspective including site ergonomics and, plant and equipment. Accident reporting is not efficient part of site culture as contract based or daily wage workers have job insecurity which leads number of incidents to a severe accident. There is clear weak relation between lagging and leading indicators of safety performance as most accidents are happening due to tools but workers perceive that proper PPE is provided and no tools are defective. In light of current study, it is recommended that construction firms should provide tools and equipment without defects and well maintained site environment.

### **Keywords**

Accidents, Safety climate, Workers, Safety performance, Pakistan

## 1. Introduction

Construction ranked third among most hazardous industries in Pakistan with high injuries, occupational diseases (PBS, 2011) and fatalities rates (both reported and unreported). Earlier research showed poor safety culture (Farooqui et al. 2007) with inadequate safety management system (Farooqui et al. 2008; Choudhry et al. 2012), safety climate with weak perceptions (Masood et al. 2011), uncertainty avoidance attitude and non-practice behavior (Ali.T.H, 2006; Masood et al. 2012a;) in situation with saturation of many safety rules and regulations with less application caused negligence towards labour law in context of safety (Raheem et al. 2011; Jafri et al. 2012). Workers working in a more collectivist, feminist, and higher uncertainty avoidance environment, are more likely to have safety awareness and beliefs and thus exhibit safer work behavior (Mohamed et al. 2009). Current study focused to relate safety management and perception based performance indicators to investigate the common accidents/injuries and perceptions of employees.

Construction safety is the action of keeping safe and safety is a contrivance to prevent injury or avert danger, and attributed as a mechanism to prevent the occurrence of an accident (Nugraheni, 2009). (Grimaldi 1970) claimed that accident statistics are insensitive, and cannot reliably measure safety. One major disadvantage of conventional safety measures is that they are retrospective, measuring unsafe behavior after it has occurred (Rockwell and Bhise 1970; Tarrant 1970). It is widely accepted that unsafe behavior is intrinsically linked to workplace accidents. A positive correlation exists between workers' safe behavior and the safety climate within construction site environments. Construction workers' attitudes towards safety are influenced by their perceptions of risk, management, safety rules and procedures. Addressing measures for safety e.g., accident rates and compensation costs often means that the "success of safety is measured by the levels of system failure" (Cohen, 2002). In recent years, there has been a movement away from safety measures purely based on retrospective data or "lagging indicators," such as accident rates, toward so-called "leading indicators" such as site investigation and measurements of safety climate (Flin et al. 2000). Leading indicators are upstream, predictive, heading and positive but lagging indicators are downstream, historical, trailing and negative.

Toellner (2001) describes lagging indicators as measurements that are linked to the outcomes of an accident such as injuries and fatalities. Accidents on construction sites occur either due to lack of knowledge or training, a lack of supervision, or a lack of means to carry out the task safely, or alternatively, due to an error of judgment, carelessness, or apathy (Teo et al. 2004; Fang et al. 2004). Injuries can be categorized into first aid injuries; medical injuries (no lost work shifts); disabling injuries (where at least one shift is lost) which can either be permanent or temporary in nature; and fatal injuries (Compensation for Occupational Injuries and Diseases Act, 130 of 1993).

Studies have shown that hazards can be controlled and accidents can be prevented through the implementation of basic safety practices leading to a sound safety program (Sawacha et al. 1999; Choudhry et al. 2008). Physical injuries and indeed fatal injuries receive the most attention from employers because of the direct costs associated with them. Not all accidents result in injury or damage to equipment or material. It is in fact the near misses, those accidents that don't result in injury or damage that hold valuable answers to what the future holds (Hinze 2006).

Safety climate can influence safety performance (Wu et al, 2008) and most valid leading indicator. Choudhry et al. (2007) provided the definition that *safety climate reflects employees' perceptions about the organizations' safety management system including policies, practices, and procedures that show how safety is implemented in construction sites environments*. The influence of safety climate on individual safety behavior transfers to safety performance, termed as effective way (Fang et al. 2006). There is consensus among researchers that safety climate is vital measuring construct (psychological) of safety culture and named in various ways as product (Cooper et al. 1994); manifestation (Cox et al. 1998); indicator (Gadd, 2002); abstraction (Mearn et al. 2003); and snapshot (Fang et al. 2006). Budworth (1997) refers to measuring the safety climate as taking the "safety temperature" of an organization.

Research studies provided evidence of correlation through identified dimensions or factors, a measure of safety climate with safety performance (Findley et al. 2007).

## **2. Lagging vs Leading Indicators**

Leading performance indicators (Safety climate) have the advantage of identifying weaknesses in safety management practices before they manifest as accidents i.e. lagging indicators (Mearns et al. 2003). Prioritizing and valuing safety (i.e., having a positive safety climate) have been shown to enhance safety performance and decrease employee injuries (Zohar, 2002). Recent meta-analytic evidence has confirmed that safety climate is associated with greater safety performance and decreased rates of accidents and injuries (Gittleman et al. 2010). Guldenmund (2000) concluded that safety climate might be considered as an alternative safety performance indicator. Actually the power of the safety concept lies in its ability to predict safety performance (Pousette et al. 2008).

Hinze et al. (2013) characterize leading indicators of safety performance as consisting of a set of selected measures that describe the level of effectiveness of the safety process. Leading indicators measure the building blocks of the safety culture of a project or company. When one or more of these measures suggest that some aspect of the safety process is weak or weakening, interventions can be implemented to improve the safety process and there by positively impact the safety process before any negative occurrences (injuries) are sustained.

Coyle et al (1995) found relationship between safety climate analysis and other positive performance (leading) indicators of occupational safety and health which can be classified as passive in context of a firm or a project (management personnel, field employees, subcontractor election, subcontractor site safety program, subcontractor commitment for worker safety) and active subject to short term change (toolbox meeting, pre-task planning, drug test, number of close calls, safety audits, owner promotion, worker observation record).

With lagging indicators, the need for change in the safety program is not realized until at least one injury has been sustained and leading indicators are viable and promising alternative to consider. Mengolini and Debarberis (2008) support this position stating that past performance is a poor predictor of future results. Additionally, an unbalanced focus on lagging after-the fact based measures may convey an unintended message that safety prevention is less important. Knowledge of accidents in terms of injuries and fatalities helps to identify the key perception (safety climate) aspects which need to align for improving safety culture on construction sites.

## **3. Methodology**

Initially, construction accidents were investigated and validated from various resources. Secondly, identified accidents were further investigated for safety climate (perception). Lastly, Relation has been developed between both lagging and leading indicators on comparative grounds.

## **4. Construction Accident Trends**

In Pakistan, average increase in construction related injuries and diseases were observed according to relative percentage 12.54 (2002) to 13.10 (2011), construction industry is ranked 3<sup>rd</sup> in most hazardous industries of the country (PBS), most companies have an average fatality rate per project in the range of 2-5% of the total project work force (Farooqui et al. 2009). Construction sites normally recorded accidents occurring during execution of project activities (Choudhry et al. 2012b) but accident reporting and recording system are dysfunctional (Ali, 2006). Procedures for accident reporting and investigation, mechanisms for implementation of safety work rules, processes for safety record keeping and logging, methods for accident response, and practices for safety performance evaluation are not suitably applied by majority of contractors. However, – more because of a practice – jobsite safety inspections, site layout

planning and provision of first aid facilities on site are relatively stronger implementation areas of safety (Farooqui et al. 2009).

*Table 1: Ranking of Types of injuries in chronological studies.*

Type of Injury	Investigators		
	Qazi et al. 2006	Farooqui et al. 2009	Anis, F. 2011
Fall injuries	2	1	2
Struck-by injuries	1	2	3
Injuries by wastage and raw materials	1	3	-
Heat Stroke	4	4	1
Head Injuries	4	5	1
Eye injuries	3	6	1
Burning cases	4	7	1

Following are the research studies done to investigate construction accident trends in Pakistan:

- *Qazi et al. 2006*; Major causes of injuries cave-in due to less shoring during excavation; falling from scaffolding while working on high levels; damage to eye while cutting wood or steel; lack of care and maintenance to tools as welding plants, electronic equipment, and temporarily laid power lines
- *Farooqui et al. 2009*; According to the survey response, the major injuries faced by contracting firms on their project sites, in descending order of occurrence, are given as follows (the percentages in parenthesis indicate the weighted average percentages of the injuries based on a combined proportion of percentage of occurrence of the injury and percentage of companies facing the injury): 1. Fall injuries (55%) 2. Struck-by injuries (53%) 3. Injuries by wastage and raw materials (36%) 4. Heat stroke (33%) 5. Head injuries (25%) 6. Eye injuries (21%) 7. Burning cases (9%). Falling from height has been found as one of the major causes of construction fatality. From company safety records, it was found that falling from roofs and floor openings was the major cause of such injuries. In order to prevent such injuries and fatalities, contractors reported use of safety belts, ropes and cables. Safety nets were also reported to be used by few contractors. However, looking at the high value of weighted percentage of fall injuries (55%), it can be asserted that these safety measures were either not available to most workers on site or were not required to be adopted by them as part of the site safety management system. Further diagnostic is needed to substantiate this inference. It was also found that there were a small percentage of contractors not reporting use of any of the safety harness, even though it constituted a major proportion of their accidents. Hit by falling materials was related to be a major source of struck-by accidents by many contractors. Similarly, hit by private vehicles was also found to be a prime cause of struck-by accidents on sites. Using hoist and cranes requires extra cautions in this respect; most contractors indicated that they ensure that workers are not allowed to walk beneath the hoist and cranes. Also, according to a majority, due care was given not to exceed the capacity of the hoist crane. An appreciable proportion of contractors reported to have faced situations whereby their workers had fracture cases owing to injuries caused by improper house keeping such as inappropriate material storage (e.g. wood pieces, steel pieces and nails). Heat stroke was also reported as another frequent cause of injuries on sites.
- *Anis, F. (2011)*; The primary goal of this research was to study the different accident theories in construction thus to acquire the basic knowledge about the construction accidents and to find out the root causes of accidents at building projects (High Rise), by conducting a questionnaire based survey, so that the industry practitioner may get the necessary knowledge. Statistical analysis was employed to understand the characteristics and determine the leading factors that contribute to construction accidents. The following results were obtained: The most common type of accidents in are the tool accidents (38%), fall from height (21%) and Struck by material (19%);

Most of the accidents occurred during the first hours of the day and during the summer season; Most of the workers involved in the accidents were unskilled labor and their literacy rate was very low; The main cause of Construction accidents in Pakistan are related to Management and Project nature factors, while the workers and job and social factors were having no large affect, which is an unexpected result. Both workers and supervisors agreed on the ranking of the accident factors.

According to 2011 Annual Report of CIWCE & IRI, Lahore, Pakistan, there were around two fatalities and six injuries related to defective tools and fall from height, as reported in local newspaper addressing whole country. It may also be kept in mind that sectors like transport, services, agriculture, and construction are not covered under the labour protection laws. So the victims do not receive any of the benefits like compensation, injury benefits, death grants and social security coverage available to workers in manufacturing sector. Accident causes due to fall from height and use of defective tools and plant were focused for further investigations for safety climate survey.

### **5. Safety Climate Survey**

A safety climate questionnaire was adopted previously used for study by Masood et al. (2011) with statements related to construction accidents. The questionnaire was based on a five-point Likert - type (from 1 = "strongly disagree" to 5 = "strongly agree"), survey was conducted on twenty three construction sites of diversified types as infrastructure, high rise buildings, facility buildings, roads and bridges. 76% of response have been received from sixty one workers of different trades (for work, steel fixing, concreting, plaster, scaffolding and related helpers). Mean safety climate score (MCSC) was used by Masood et al. (2012) which represents average value upon Likert score against all safety items, further evaluates weak or strong perception regarding safety. Results showed mean score of safety climate statements (related to construction hazardous, incidents and accidents) revealed as investigations are mainly used to identify who is to blame (3.61); People are just unlucky to suffer an accident.(3.28); my supervisor/safety manager welcomes reporting safety hazards/incidents (3.70); and accidents which happen here are always reported (3.82); Productivity is usually seen as more important than health and safety by management (3.24); Sufficient resources are available for health and safety here (3.35); in our work environment working with defective equipment is not allowed under any circumstances (3.61); People can always get the equipment which is needed to work to the health and safety procedures / instructions / rules (3.61); Some jobs here are difficult to do safely (3.24); and Current safety rules and procedures enforce the use of personal protective equipment whenever necessary (3.68).

### **6. Conclusions and Discussion**

Accident records are kept but the use of statistics are not appropriate even when there is investigations on construction sites main emphasis is on the blame game among workers, supervisors and managers. Unfortunately, there is no mechanism for compensation for injury or death because of less implementation of inadequate law. This rise uncertainty among the workers and they initially blame their luck which make them victim of construction accident. There is contradiction about reporting accident or near miss to supervisor or manager because not all the accidents are reported and considered. Anis (2011) found workers related factors which contribute in happening of accidents;

- The worker was suffering from health problems
- Worker was rushing the work
- Worker was not wearing personal protection items(PPE)
- Physical fatigue caused the accident
- The worker had no satisfaction with the nature of the job
- The accident occurred due to misjudgment from the worker

Specifically, two critical types of accidents associated with Pakistan construction sites as learnt in previous sections. Workers are not allowed to use defective tools or equipment on sites but due to rush of work they have to work with these without wearing PPE. Workers are not skilled to operate all the tools

or equipment e.g. drill machine, welding plant, batching plant etc., and not all the workers are physically strong to do so.

Fall from height is another type of accident which is normally prevailed. Fall from opening or edge or from ladder are the ways this accident can happen. Workers are not wearing proper PPE and they also misjudge the situation due to sufficient resources to execute the activity. Moreover focus on productivity also caused this type of accident.

There is wide difference in situational and perceptual aspects of safety performance. Current study indicated main accidents under lagging indicator of safety performance and their acceptance at perceptual level which showed weak relation between subjected indicators.

Responsibility of accidents is not taken by either management or workers but role of supervisors is also critical which relate safety issues with self-performance. Productivity has given priority on safety due to tight schedules on construction projects which urge managers and supervisors to ignore hazardous conditions. Major reason of accident is defective equipment endorsed in psychological perspective including site ergonomics and, plant and equipment. Accident reporting is not efficient part of site culture as contract based or daily wage workers have job insecurity which leads number of incidents to a severe accident. In light of current study, it is recommended that construction firms should provide tools and equipment without defects and well maintained site environment.

Current studies showed leading indicator (i.e. safety climate) highlights the lack or use of defective PPE and productivity as priority while working. If these two factors are properly addressed then lagging indicators (i.e. accident records) can be reduced. Both the indicators are significantly related to enhance safety performance on construction projects.

## **7. Acknowledgement**

This research project (ID: UOL-CE-R-02-2013) is funded by The University of Lahore (UOL), Lahore, Pakistan.

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