EFFECTS OF POOR SITE SAFETY ON COST OF A MEGA CONSTRUCTION PROJECT

CASE STUDY OF ORANGE LINE METRO TRAIN LAHORE

FINAL YEAR PROJECT UG 2015

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Islamabad, Pakistan

(2019)

This is to certify that the final year project titled

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THESIS

Submitted to National University of Sciences and Technology in partial fulfilment of the requirements for the BE degree

In

CIVIL ENGINEERING

_____

Project Advisor

Mr. **Lecturer M Hasnain**

Date

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ABSTRACT

Safety at a construction site has always been a daunting task worldwide. At a construction site due to repetition of activities, hectic work routine, dangerous and life-threatening activities, accidents are highly likely to occur. According to statistics of ILO-18 there are about 340 million reported occupational accidents occur annually and among such accidents 38% is contributed by the construction industry. From this it can be envisaged that how drastic the safety situation is in this industry. In-case of Pakistan the safety situation is more critical as the reporting mechanism for the site accidents is not satisfactory. In order to determine the current site safety situation and their effects on the cost and economy of a project we took the case study of and ongoing mega project of rapid transit which is Orange Line Metro Train, Lahore. At the start of this study approximately 60% of the project was done.

By the help of surveys conducted, on the sites of orange line Lahore we executed on site interviews and filled questionnaires to collect the data regarding the details of any site accident, victims of that accident, direct cost incurred in such accident and recovery provided etc. Those 116 questionnaires containing the data were transferred to the soft form using the Microsoft excel and SPSS. The data gathered, was then analysed for getting results. Results from the data enabled us to determine the root causes for the poor site safety situation by the help of classification of such accidents.

The results were then used to build a Risk chart which basically consisted of probability of the accident and severity of the accident in terms of cost (where cost is directly proportional to the human loss) and their product as Risk. By using the Risk chart, we ranked each class and cause of site accident. After making the Risk chart we made a Sun burst chart in which each class of accident was further corelated with its causes and with its prevalent remedies to cater such type of accidents. The developed ranking would help out the authorities and managers to invest in such field/classes of safety in order to avoid such type of site accidents in such type of rapid transit projects so that it can be made sure that there would be no losses of lives and finance in such project due to safety issues.

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CERTIFICATE OF ORIGINALITY

We hereby declare that this submission of Final Year Project is our own work and that, to the best of my knowledge, faith and belief, it contains no research/study material previously published or written by any other individual, nor material which to a significant extent has been accepted for the award of any other degree at NUST or any other educational institution, except where due acknowledgment is made in this thesis. Any contribution made to this research by any intellectual and colleague is explicitly acknowledged and accredited.

EFFECTS OF POOR SITE SAFETY ON COST OF A MEGA CONSTRUCTION PROJECT

CASE STUDY OF ORANGE LINE METRO TRAIN LAHORE

DEDICATION

We dedicate our work to our dear family and instructors who empowered us to achieve education to get learned and meet our goals and objectives with such dignity and respect unreservedly. They supported us at every step of our lives and hence enabled us to reach up-till here.

EFFECTS OF POOR SITE SAFETY ON COST OF A MEGA CONSTRUCTION PROJECT

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ACKNOWLEDGEMENT

We are deeply and modestly appreciative to acknowledge and show gratitude to those people who put their utmost contribution into our final year project and hence the thesis without demanding any favour. First of all, thanks to Almighty Allah for blessing us with everything that he has provided us in life and for guiding us the right path at every moment of life.

We would like to pay our hearted recognition to our project advisor **Lecturer Sir M Hasnain Munir** who enthused us through his advice and guidance and helped us at every step whenever required. During the entire period of our project under his supervision he always did his best effort, showed patience, information, best of his knowledge and honesty. We would also like to extend our appreciation to our ever-best faculty members **Sir Dr Abdul Waheed**, **Sir Dr Usman Hassan and HOD CE&M Sir Dr Khurram Iqbal Khan** for his constant support, help and provision of their precious time unconditionally.

NUST has been amazing journey for us. The teachers have been very helpful throughout these four years and the facilities provided to us, the labs, equipment and machinery, everything was of top quality. The lab engineers and attendants were very cooperative, and we are thankful from the depth of our hearts to NUST for making our engineering and studies enjoyable and worthwhile.

In the end we appreciate the support and praise provided by our families throughout our academic career and life, for if it were not present, we may not have been where we are now.

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LIST OF ABBREVIATIONS

PPE	-	Personal Protective Equipment
PMA	-	Punjab Masstransit Authority
DFID	-	Department for International Development
EMS	-	Emergency Medical Service
GDP	-	Gross Domestic Product
LDA	-	Lahore Development Authority
NHA	-	National Highway Authority
NRSS	-	National Road Safety Secretariat
LMRCL	-	Lucknow Metro Rail Corporation Limited
RII	-	Relative Importance Index
SPSS	-	Statistical Package for Social Sciences
OLMT	-	Orange Line Metro Train Lahore

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Background

In today's world the safety of human beings is one of the most important and valuable things. The life of human beings is the most precious thing on earth. According to the historical document of human rights (**The Universal Declaration of Human Rights**) **"**Everyone has the right to life, liberty and security of person**''**. But on job site, very less attention is being given for the safety of the workers/labourers, especially in third world countries like Pakistan.

Occupational Accidents

According to ILO occupational accidents are defined as any unexpected and inadvertent manifestation which includes acts of violence, arising directly or indirectly due to any activity related with the work which results in one or more worker's injury, disease or death.

Due to lack of awareness labourers don't pay importance to personal safety and as a result they either waste their body part for the rest of the life or ruin their lives to death. In site safety management and provision clients, consultants and contractors have their own perspective and role.

The most common workplace accidents on construction sites and are workforce related which occur due to lack of safety measures that are as follows:

- Slips and trips.
- Falls from heights.
- Trench collapse.
- Scaffold collapse.
- Misuse of proper PPE.

- Repetitive motion injuries.
- Struck by moving vehicles.
- Hit by flying or falling objects.
- Electrocution.
- Burnt because of heat from the equipment.
- Ladder fall due to improper use
- Respiratory problems due to ignorance of safety measures

  Among the type of accidents mentioned above, fall is the most frequent type of accident which occurs on a construction site

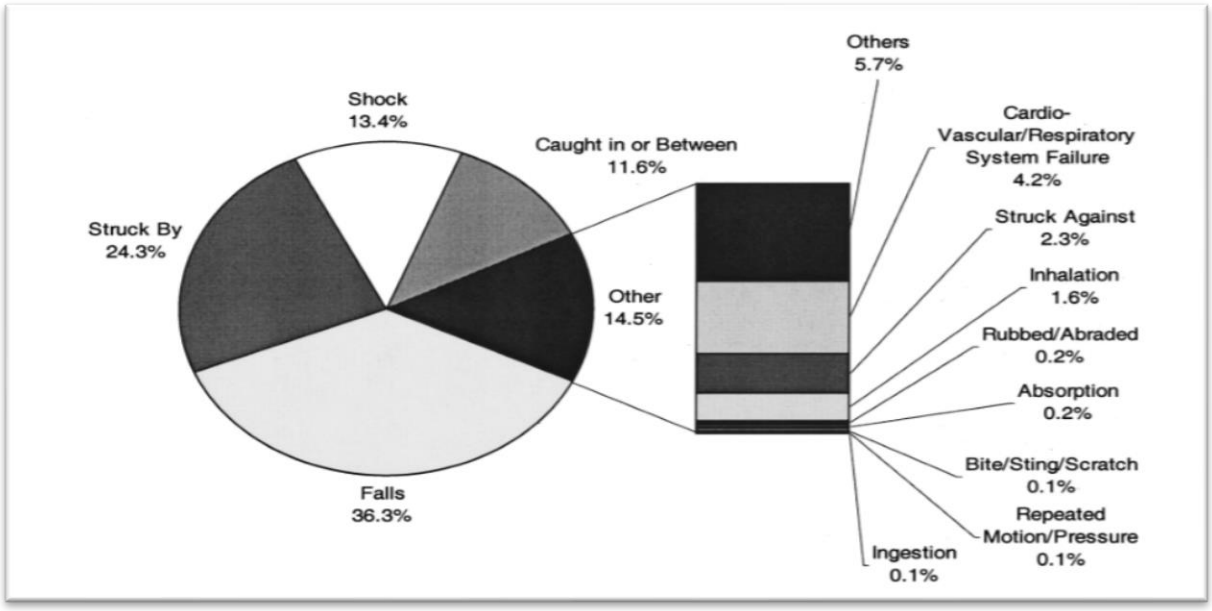


Fig.1

Stats by OSHA-2001

The above mentioned percentage is increasing with the passage of time**(Huang and Hinze 2003)**.

1.1 Problem Statement

In Pakistan, site safety is usually taken as for granted specially for the workers and labourers. The authorities don't invest seriously adequate amount on the safety of the workers and staff

due to which they encounter unplanned and unwanted delays and eventually they have to bear financial losses which collectively causes the increase in budgeted cost of a project.

This project is to determine the loss of direct cost due to accidents because of poor site safety practices in a construction project in Pakistan.

1.2 Research Gap

Selection of case study*:*

Following were the causes of selection of such case study


THE EXPRESS TRIBUNE > PAKISTAN > PUNJAB

Orange Line accident: Labour Dept expects report on safety standards today

By Amel Ghani Published: January 20, 2016

Fig.2

THE EXPRESS TRIBUNE > PAKISTAN > PUNJAB

Four wounded OLMT workers fight for their lives

By Our Correspondent Published: June 21, 2017

0 SHARES SHARE TWEET EMAIL

Fig.3

LAHORE: The Orange Line Metro Train Project on Sunday claimed four more lives as a heavy dumper knocked down a motorbike and a Qingqi rickshaw at the construction site in Lahore, Samaa reported.

According to our correspondent, the incident took place in Lahore's Daroghawala area where a fast-moving dumper hit a bike and a three-wheeler carrying six people.

Fig.4

Seven workers hired for Orange Line Train project perish in fire

Imran Gabol | Updated January 12, 2017

Fig.5

The safety conditions were so miserable that due to higher number of onsite accidents, owner of one of the two primary contractors had to face a FIR against him.

1.2.1.1 Orange Line Metro Train Lahore

Orange line is an automated rapid transit system for public conveyance in provincial capital of Punjab, Lahore. During our course research project which is among the particular requirements of the degree the Orange line project was under construction. It is the first metro train of Pakistan. The track of orange line runs through some busy and highly commuted routes. The route map is as follows:

Fig.6

Technical Details

- The locomotives of orange line would be electrically operated.
- It has a track length of 27.1 km (25.4km elevated, 1.72km underground)
- It has 26 stations (24 elevated, 2 underground)
- Its track gauge is **1435mm** (similar to metro trains worldwide)
- Its electrical supply is 750 V DC

- Its operating speed is 80kmph
- The length of its longest station is 125m (Anarkali Station)

Financial Details

- The total cost of the project is approximately $1.8 billion.
- Out of US$1.8billion, US$1billion was directly transferred to the Chinese contractors while the remaining US$0.8billion was handed over to the Pakistani contractor for the construction works.
- The finance is provided by the Exim bank of China as a soft loan
- It is now broadly the part of the famous China Pakistan Economic Corridor(CPEC)
- It has 3 packages, package1(Dera Gujran-Chauburji), package2(Chauburji-Ali Town) and Package 3(Train Depot at Dera Gujran)
- Package 1 and 3 construction works costs about US$200million while that of package 2 as US$120million.
- Package 1 and 3 were under the same contractor (National) while the package 2 was given to the other contractor (National).
- Orange line Lahore is the only project of its kind worldwide in which the cost of rolling stock, track, electrical and mechanical works cost about double of the civil works.

Operational Details

- Each train of orange line consists of 5 cars each of having rider capacity of 200 persons.
- It is expected to have about 27 trains in the system by 2019 and more than 50 by 2025
- The expected ridership of orange line train is approximately 250000-300000 **(https://pma.punjab.gov.pk/olmts)**

Controversies & Schedule Delays

- The overall project is 22 months ahead of schedule.
- On some of the sites near the historical places there had been a stay taken by court for as long as of 8 months.
- Orange line project has several transparency issues.

Objectives

After carefully analysing the approachable sites, we selected Lahore Orange Line Metro as it was already in news that the project is experiencing several site accidents. The objectives of the project using this case study are:

- To determine the types and causes of accidents on the site.
- To determine the direct cost loss due to these accidents.
- To propose an approach for investment in different safety measures mitigating different causes of accidents.

1.4 Brief Description

Contrary to other hardcore industries possessing sophisticated safety threats and risks the construction industry has the traits of small scale of accidents with higher frequency and diverse danger sources. It can be contingent that safety in the field of construction is a perennial universal problem. It is ostensible that the construction sector is way far from the divine concept of "zero accidents/injuries" advocated by several construction firms.

ILO estimates that more than **2.3 million women and men** globally capitulate to occupational accidents or diseases every year; this corresponds to over 6000 deaths each day. Globally, about 340 million work related accidents are reported and 160 million victims of occupational illnesses annually. Moreover,

- 20% of the labour of construction companies encounter traumatic injuries worldwide
- Approximately 12% of total disabling injuries occurs in construction industry
- 6-10 fatalities on construction sites occur every day.

ILO states these estimates at a regular interval, and these updates indicate rapid increase in accidents and degradation of human health. This research work is to conclude the site safety conditions at construction sites in Pakistan. In this project we will find out the factors which retard the site safety works and hence affect the project in different manners. We will conduct surveys to collect information and opinion about importance of safety at site from different stakeholders in construction industry in Pakistan.

Organization of Thesis

This thesis is composed of following chapters, the detail of each one is discussed below:

Chapter 1

It includes the Introduction having the background, problem statement, research gap, objectives and brief introduction of the project

Chapter 2

It includes Literature review having introduction, behaviour towards safety, on site accidents, cost of accidents in construction industry, human resources and safety, project economy and site safety, factors causing cost overrun and risk factors for cost of a project.

Chapter 3

It includes methodology having general background information, preparation of questionnaires, conduction of surveys, extraction of data, compilation of data and compilation of results for examination.

Chapter 4

It includes the analysis and results of data collected form the site surveys, interviews and questionnaires and a comparative study of a relevant project that took place simultaneously in India.

Chapter 5

It includes the limitations during the conduction of this project and further recommendations for research in future

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The emphasis of this part of study is to provide an outline of the work already done by our seniors/leaders/high-ups in this field, on this topic and related to this scope. Safety is a process by which any injury or accident can be avoided, whereas in construction field safety is defined as the process by which the lives of those who build, operate, maintain, renovate and demolish engineering/construction works.

2.2.1 Safety in Construction Industry

Construction usually has relatively higher accident rate as compared to other fields and industries because of diversified human behaviour, vast human interaction, impulsive site conditions, unsafe procedures and unique nature of the industry **(Choudhry and Fang 2008)**.

2.2.2 Behaviour Towards Safety

In the construction industry safety is regarded as a point of concern, as it is among the most dangerous and unpredictable industries worldwide. Specially in developing countries where there is lack of safety acts (Mohamed, Ali et al. 2009).Safety climate is regarded as safety culture manifestation in behaviour expressed in the attitude of employees(Cox and Flin 1998).

2.2.3 Safety Climate for Safe Work

The fig shown below elaborates that the safe work attitude is the result of the safety culture which is dependent on some autonomous factors that are mentioned as follows:

- Safety
- Risk
- Management

- Work pressure
- Competence

Due to the factors mentioned above the model has three distinct components i.e

- Antecedents to safety climate
- Safety climate (Worker's perception of safety climate)
- Outcome of safety climate

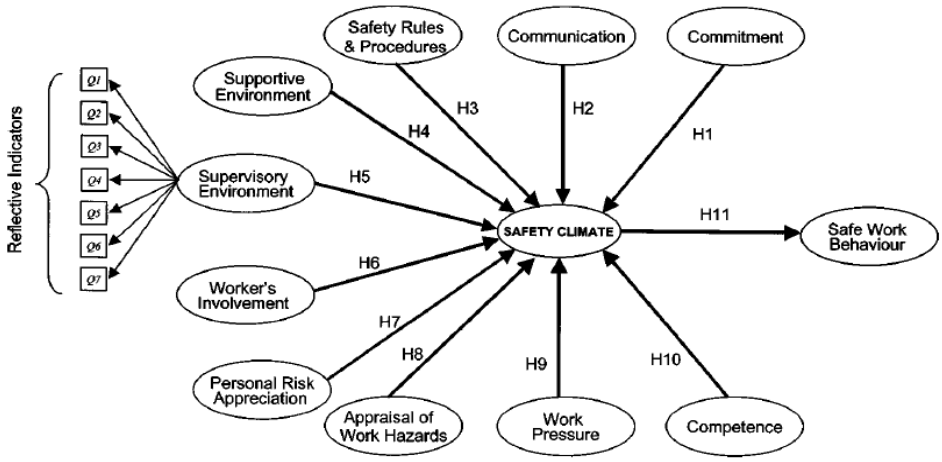


Fig. 1. Research model and hypotheses. Reflective indicators are shown only for one construct for simplicity of presentation.

(Mohamed 2002) **Fig.7**

2.2.4 Risk to Cost and Schedule of a Project

The safety situation and behaviour towards its enforcement can be envisaged from this that **''**Neither clients nor consultants are concerned with a contractor having an appropriate health and safety management system.**''**

This significantly removes the responsibility of labourer's safety from the contractor.

2.2.5 On Site Accidents

In construction industry, usually accidents are due to the human error and negligence. Human error is defined by Rigby(1970) as **‘’**Any one set of human actions that exceeds some limit of acceptability**’’ (Abdelhamid and Everett 2000).**Construction usually has relatively higher accident rate as compared to other fields because of diverse human behaviour, impulsive site conditions, unsafe operations and exceptional nature of industry**(Choudhry and Fang 2008)**.

2.2.6 Cost of Accidents in Construction Industry

In the year 1979, the Business Roundtable (BR) custom-built the research to conclude the true cost of accidents and injuries in construction sector. Strangely BR summarized that construction site accidents, fatalities and injuries cost approximately 6.7% of the industrial, commercial and residential construction.

2.2.7 Human Resource and Safety

Safety training is an important and usually very effective tool of Human resource for mitigating accidents at construction sites**(Tam, Fung IV et al. 2001)**.Similarly effective HR practices lead to positive and fruitful organizational and institutional consequences like revenue and productivity**(Becker and Gerhart 1996)**.The selection of individuals with relevant working experience, also reduces the HR related risks at site and also produces better safety outcomes. In Hansen’s causal model relationship among accidents it showed that insufficient experience of a job or a task also majorly subsidises to site accidents which are devastating**(Hansen 1989)**.

2.2.8 Project economy and site safety

In the modern construction world, economic and low-cost construction is getting pace day by day specially for residential sector. But there should be no compromise on safety while dealing with project cost and economy.**(Morelli 2011)**.

2.2.9 Factors causing cost overrun

According to an Afghanistan based research paper, safety is ranked at 63rd position out of 69 factors causing the cost overrun of a project.

61	Market inflation	External
62	Currency changes	External
63	Safety during construction activities	External
64	Legal disputes between parties	External
65	Lack of definition of substantial completion	External
66	Inappropriate type of project bidding and award	External
67	Mistakes and discrepancies in contract documents	External
68	Building codes	External
69	Strikes and demonstration	External

Fig.8(Niazi and Painting 2017)

2.2.10 Risk Factors for cost and time of a project

Among the 37 factors were analysed in the survey which usually affect the cost and schedule of a project, astonishingly, health and safety hazards were ranked at the bottommost by the participants who voluntarily filled the surveys. This shows the inattention of clients and consultants to whether a contractor have a suitable health and safety management system or not which itself is a disaster.

Table 1. Relative Importance Index of Risk Categories

Risk category	Relative importance index
Financial risk	69.95
External risk	66.67
Design risk	66.28
Management risk	65.17
Construction risk	62.72
Contractual risk	59.42
Health and safety risk	53.82

Fig.9

This RI index was developed on the basis of the data collected by the help of questionnaires conducted on sites with the concerned personnel. **(Choudhry, Aslam et al. 2014)**

2.2.11 Role of Individuals and Personnel Selection

The concept of accident proneness objected the personnel selection method of accident control. Risk analysts in 1920s noticed that a greater percentage of a firm's accidents was caused by a relatively smaller percentage of employees. This led to the verdict that some employees were more accident prone than others. Researchers branded some variables that can be useful in screening of future employees namely personal maladjustment, social maladjustment, impulsivity and cognitive deficits (Guastello 1993). However, when tested for personnel selection, the technique emerged as least effective method for improving occupational safety (Guastello 1993). Recent studies also show comparable results, which conclude that the characteristics of individuals in construction industry among construction workers don't play as much role in the occupational accidents **(Chau et al. 2002)**.

2.2.12 Role of Technology in Site Safety

Technological advancements and involvements can be categorized into automation (Karwowski et al. 1988) and comprehensive facility redesign. Nevertheless, the outcome of the intercession brings human errors with it in package that are typical with introduction of any new system and technology. For illustration, automation intrusions have the potential to decrease the no of accidents, but they also give birth to some new types of accidents (Chignell et al. 1986). To alleviate the situation, new techniques and control measures have emerged in the form of emergency switch usually operated by workers at site to arcade the operation (Sjostrom 1990), a sensor which detects and senses the presence of workers at the work space, or re-fabricating the work-stations totally eliminating the requirement of the physical presence of workers. Technological achievements and involvements have been utilized in the construction industry to improvise the safety of specific construction operation, such as the use

of robotics in the pipe laying industry. The benefit can be envisaged by reduction of accidents and also reduction in cost by not having to adhere to rigorous safety rules and guidelines **(Bhattacharjee, Ghosh et al. 2011)**

2.2.13 Labour Accidents in Pakistan

Pakistan as a developing country undergoing a boom in its construction industry for a past few years, with more than 3 million workers employed by this industry. In Pakistan construction workers constitute about 7.48% of the labour force, while the construction injuries and fatalities epitomise about 17% of the whole labour force injuries and fatalities **(PBS,2012)**

2.2.14 Obstacles Hindering Safety Improvement

The fig below shows some of the obstacles which are hindering the process of improvement of safety conditions in Pakistan.

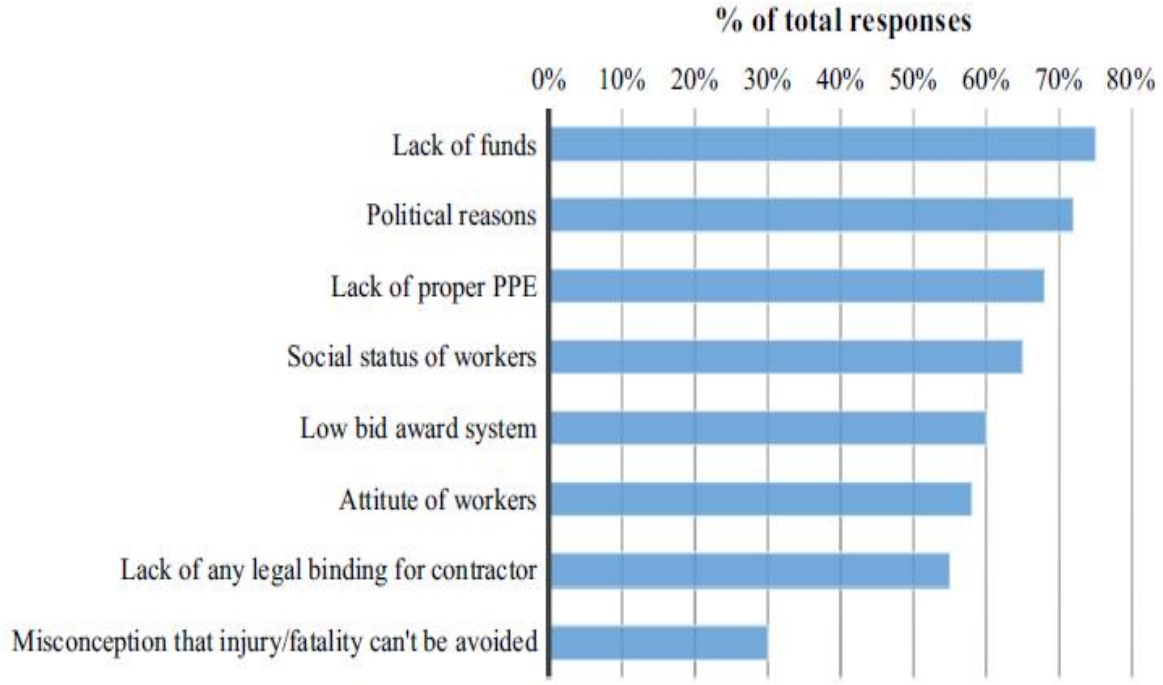


Fig. 8. Obstacles that can hinder the safety improvement process as listed by the panelists.

(Mohamed 2002) **Fig.10**

2.2.15 Worker's Perception of Risk at Site

Globally, the perception that construction worker's attitude towards safety is growing as it is greatly inclined by their acuity of risk, management, safety rules and procedures. The paper examined behaviour, perceptions and attitudes associated with safety in construction site environments of Pakistan. An interview-based questionnaire survey was conducted focusing on workers' behaviour and perceptions. The results showed that the workers had suitable know how of the risks linked to their jobs, but they don't take it as too exhilarating; they assumed to have shared responsibility in maintaining tuneful working relationships and to prevent accidents. The respondents had a higher level of risk awareness and self-rated competence, with a relatively high degree of safety awareness**(Mohamed, Ali et al. 2009).**

2.2.16 Construction Safety Performance in Developing World

In the developed countries, safety rules and legislations are enforced effectively and dedicated safety officers indorse hazard awareness activities with the help of regular safety training programmes. On contrary, in developing countries, safety rules barely exist; and any that do are inappropriate, ineffective and out of date. Furthermore, the regulatory authorities are usually very weak in enforcing the rules effectively in essence, and work hazards are either not perceived at all, or perceived to be much less hazardous than they actually are.**(Enshassi, Choudhry et al. 2008)**

2.2.17 Factors affecting construction safety performance

According to HSE 90% of construction accidents leading to death could have been prevented by 70% efficient management actions and responses.**(Sawacha, Naoum et al. 1999)**

2.2.18 Role of subcontractors and site safety

The subcontractors and speciality contractors in the construction industry usually trust to a greater extent on their own common sense to inform their safety perceptions and decisions on site. It is assumed that common sense is linked to reflective practice, and the decisions reached through common sense very often come from critical consideration. It is developed and well-versed through participation in the process of executing construction work, which means common sense is cultivated, is not fixed and is acquiescent to change as new circumstances challenge previously held conceptions. Locating the exact sites for this learning is very imperative if changes are sought to the way construction workers manage safety. Following fig shows the surveys conducted from subcontractors regarding the site safety.

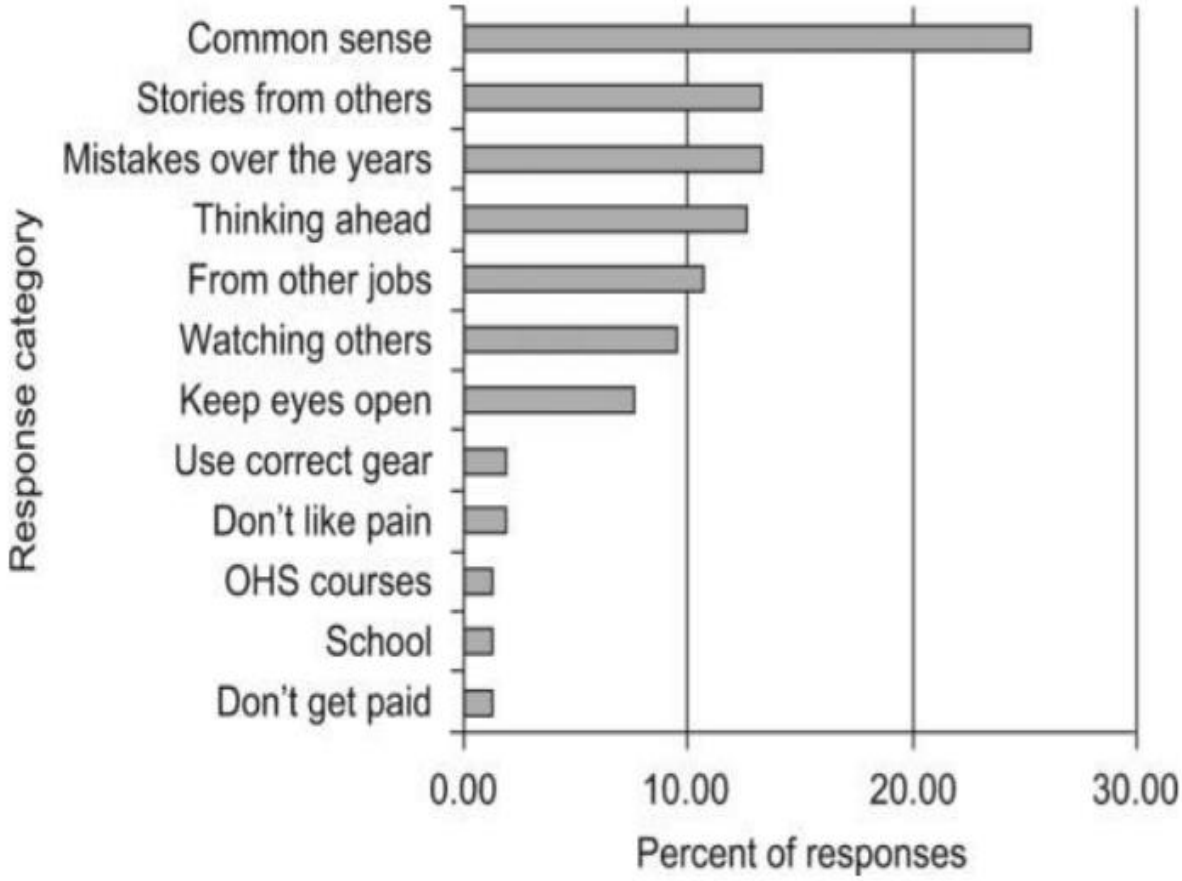


Fig.a(Wadick 2010)

CHAPTER 3

Methodology

3.1 General

This methodology has been adopted with effective strategies to investigate the total direct loss in the cost of a construction project in Pakistan and to analyse the in depth causes of construction site accidents. The effect of safe environment on cost of the project is evaluated with the help of chosen case study.

3.2 Preparation of Questionnaires

Two detailed questionnaires were developed with the help of related research papers and journals regarding site safety for efficient conduction of surveys in the span of almost two weeks. One contained information from the labourers and masons and the other for engineers, supervisors and foremen.

It contained nearly all sorts of questions regarding site safety practices and accidents occurred due to different causes and direct losses due to such accidents. The samples of questionnaires are in the Appendix 1.

3.3 Conduction of Surveys

The extensive stage of the project was conducting surveys on the site. With the help of questionnaires, the site was surveyed in 10 different within the span of 4 weeks. The construction workers i.e. labourers, painters, electricians, supervisors etc and the engineers present on the site were interviewed and the data was collected. A total of 110 people were interviewed consisting of 10 engineers and100 other construction workers.

The conduction of surveys had an important impact on the project as it laid the foundation of our project and helped in understanding the site safety practices and the types of accidents

occurred on the site. Following are some safety rules violation which were witnessed by us during our field visits during the course of our final year project

Fig.13

In the above picture one can easily see how these painters employed by a National contractor were doing the paint job without wearing any safety equipment(ppe).

Fig.14

In the figure shown above a welder is welding the metal section without any face protection, eye protection or any other required PPE.

Fig.15

Here in this case the workers were working in the HVAC room sitting on the HVAC cylinders without taking proper safety measures.

Fig.16

Fig.17

In the above case there were labourers working on a manhole for sanitary works near Lakshmi chowk. They were constructing a R.C.C manhole having a depth of 30ft. At the circumference of the hole steel rebar erected can be easily seen in the picture and the whole party of workers is working carelessly on this site without having any kind of safety equipment.

3.4 Compilation of Data

The data collected from the surveys was compiled by using Microsoft Excel and Statistical Package for the Social Sciences (SPSS). The compiled data consisted of the nature of accident, the cause of accident, the location, the information about the injury or fatality and the amount incurred due to such accident. Responses regarding safety practices on the site were also taken and compared.

3.5 Results

The collected data helped in analysing results and moreover paved way to fulfil the project's objectives which are:

Classification of accidents

Each of the accident recorded through the questionnaires were further classified into major and minor accident with both defined as follow:

Major Accident

A major injury is any injury that could potentially lead the victim to death, extended disability or permanently shranksquality of life. Following are some examples of major injuries which should be given proper attention.

- Multiple fractures
- Head, face, neck or eye injury
- Deep slashes, cuts or twinge wounds
- Gunshot injury

- Spartan or widespread burns
- Injures involving chest arrest, paralysis, epilepsy, continuous bleeding or catalepsy

Minor Accident

Injuries because of minor accidents could be painful but they would not put your life at risk as such, movement or chances of survival. Examples of minor injuries include the following:

- Narrow cuts or rashes
- Sprains and muscle strain
- Bruises and skin rashes
- Minor burns covering very limited portion of body

Causes of accidents

The causes of the accidents of concerned case study of OLMT were identified. It was also noted that a single accident occurred due to multiple causes.

Location of accidents

The geographical location of each site of accident was determined by the information gathered and by using the internet.

Below figure shows the heat map for site accidents for the route of Orange line metro train, Lahore. In this figure it can easily see that the spots/circles with high accident rate have larger diameter and show up with a red colour in case of higher accident rate. The sites with higher accident rate had some serious reasons, one of which can be determined from this statement:

"The immense pressure from higher authorities for speeding up of project with limited available resources is giving rise to several problems**''**

This statement was given by a foreman working at one of the sites mentioned below with higher accident rate (Lakshmi Chowk).

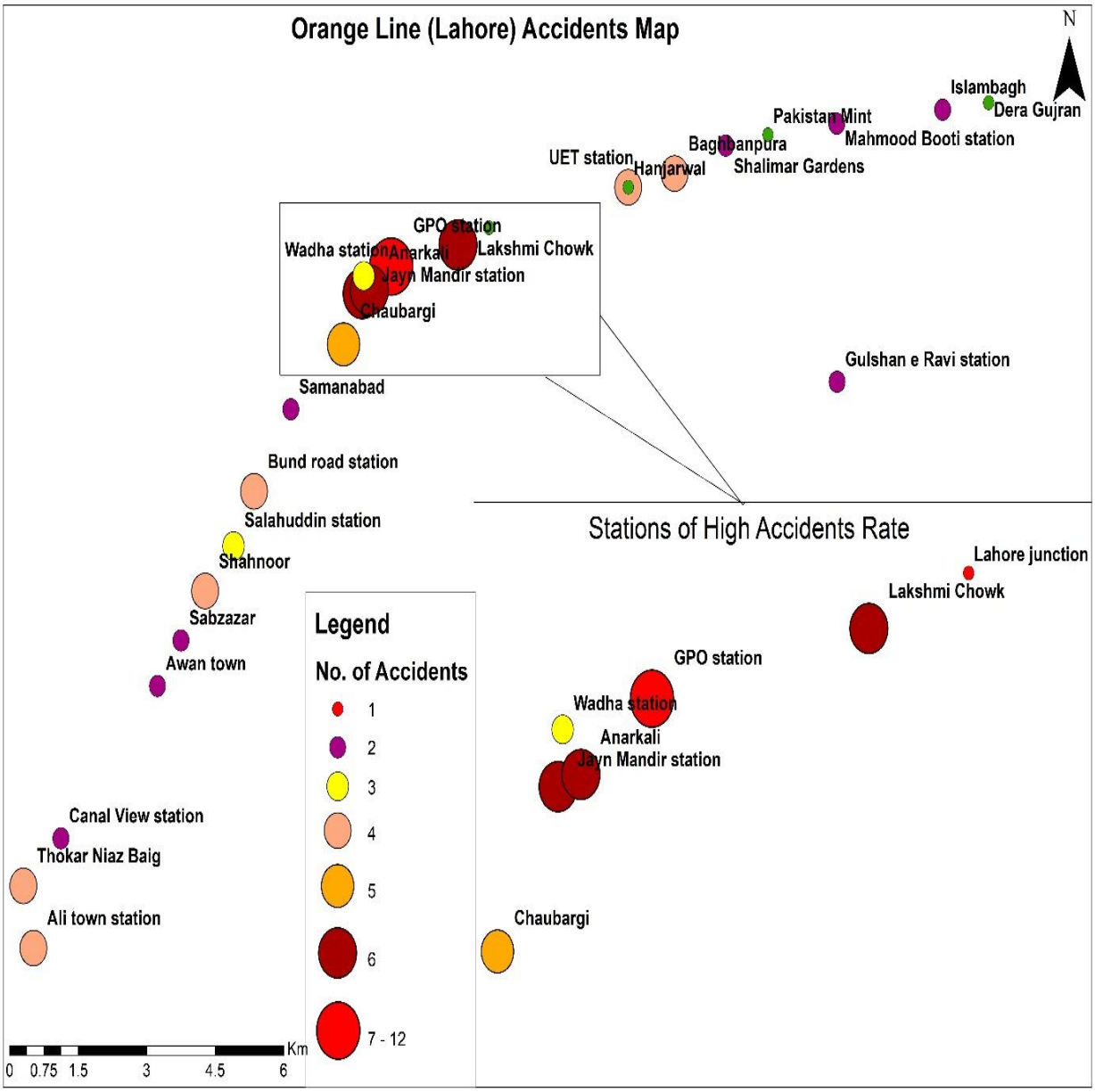


Fig.18

Direct losses due to these accidents

The total loss in direct cost due to these accidents was calculated. The loss in direct cost due to a particular class of accidents was also calculated.

Ranking of classes of accidents

The classes of accidents were ranked according to magnitude of risk. The calculation was done in analysis.

Ranking of safety measures for investment

The ranking of the safety measures was done with the help of it which gives an insight as to invest in the top ranked safety measure to mitigate the maximum loss.

CHAPTER 4

ANALYSIS OF DATA AND RESULTS

The analysis of the collected data from the surveys is done by using the following softwares:

Microsoft Excel

The data from the surveys was put into Microsoft Excel so as to conclude the information gathered. The classes of accidents were defined with the help of information from the world-famous US based law firm "Perecman" which deals with the law suit related to occupational safety claims and has defined 10 classes of accidents.

1. Falls

According to OSHA falls accounted for about 278 out of 775 (36%) as death toll in the construction industry for year 2012. An injury of this type usually occurs when a worker near any open-sided floor steps backwards or sideways without looking around. Falling risks also sometimes prevail on deep excavations when no guardrails or fences as safety measure are provided. Since high elevations often play a major role in such type of accidents, the results can be disastrous to the site workers who become victim of serious injuries and also to the equipment and structures. One of the major reasons of fatality in construction industry for such class of accidents is inadequate, or no fall protection.

2. Struck by object

About seventy-eight construction workers expired because of being struck by an object in the year 2012. The no of fatalities may have been vetoed if the workers at the relevant sites had taken adequate training and utilized proper equipment and machinery. Employees should

reminisce to apply brakes of non-moving vehicles, collision alert alarms, debris nets, catch platforms, side mirrors, safety cameras etc.

3. Electrocutions

In 2012, about 70 workers (11%) were badly injured or killed due to electrocution. Electrocution takes place when a person, tool or piece of equipment comes in contact with power lines or exposed sources of electricity. Sometimes, such type of accidents occur because workers are merely unaware of all energized power sources, around them which may be overhead and underground power lines to damaged repositories, joints, bends and connectors etc. For example, a construction worker carrying a metal ladder may come in contact with an overhead power line or there may be sparking taking place in the vicinity of the electrical cable.

4. Caught-in/between

It is pretty obvious and a matter of common sense not to stand between any equipment/machinery and an immovable object, sometimes workers focused in doing their jobs deeply to meet deadlines, find themselves trapped in some unexpected threat. Examples of such accidents include cave-ins or imploding of materials, body parts caught in the moving parts of an unwary piece of machinery, equipment rollovers and getting stuck between immobile objects.

5. Slips and falls

This is one of the most common type of accidents on a construction site which occurs. These accidents may be linked with insecure conditions including exposed holes and trenches, excavations and exposed stakes. In the year 2011 it was reported that there were probably 3335 fall related injuries reported out of which 66% were unintentional.

6. Ladder Accidents

This is among top of the list causes of major injuries and long-term disability. Most of the ladder accidents, including falls, happen because workers use erroneous type of ladders for their job or they set up the ladder inappropriately, perhaps on a greasy unbalanced or unstable surface, and the ladder unexpectedly swings or slips. Usually workers experience a foot slip, or they may lose their balance, overloading of ladder and misuse of it is also a foremost cause of such accident. In some cases, ladders are defective or improperly maintained which is the most abundant case.

7. Scaffolding Accidents

Despite of strict rules and regulations imposed by the authorities, scaffolding accidents often takes place. In a study of Bureau of Labour and Statistics (BLS),about 74% of workers injured in scaffolding related accidents attributing the accident either to the planks or support giving way. Generally, most of the scaffolding accidents occur because of inappropriate construction, poor maintenance or operating practices.

8. Power Tools and Machinery Accidents

Injuries governed by power tool and machinery usually occur for reasons like mechanical malfunctioning, electrical failure, lack of training or lack of adequate PPE. A huge count of occupational injuries is because of power tools and large equipment which may be used either improperly, operated while having lack of training or without opting adequate safety measures.

9. Musculoskeletal Disorders

One of the leading causes of injuries, permanent or temporary disability claims and medical costs in construction are ricks, strains and cramps of the muscles. The practices in construction work can cause major injuries to bones , muscles, ligaments and nerves as it includes prolonged physical exertion.

10. Vehicular Accidents

Dangerous construction site vehicles including backhoes, graders, forklifts, excavators, deep drillers, cranes, boring machines and dump trucks etc. Usually forklift accidents occur when the vehicle is maneuvered or rotated with the load being lifted. Large trucks often hit pedestrians and passer-by's during manoeuvre. Another major risk of vehicular accident on construction sites is falling from a vehicle.

As construction sites may become dangerous for the workers as well as for the visitors, many of such sort of accidents can be avoided by using common sense, future oriented mindset and protective measures. Prevention begins with adequate awareness, education and a well maintained, well managed and well-organized working environment at site as well as in the office that is safe and secure in all terms.

All the information regarding type of accidents, location, direct loss, casualties and the root cause of those accidents as well as the designation, type of injury, victim per accident, fatality per accident, concerned contractor, compensation paid for each accident to each victim and expected age group of each victim were recorded on excel. The information about site safety

practices were also separately recorded on another sheet. This paved a path to calculate the total direct cost due to the total number of accidents recorded. Furthermore, the causes of those accidents were identified by their respective classes.

Fig below shows the %age with respect to age of the victims having the victims of age group 25-30 to be the highest.

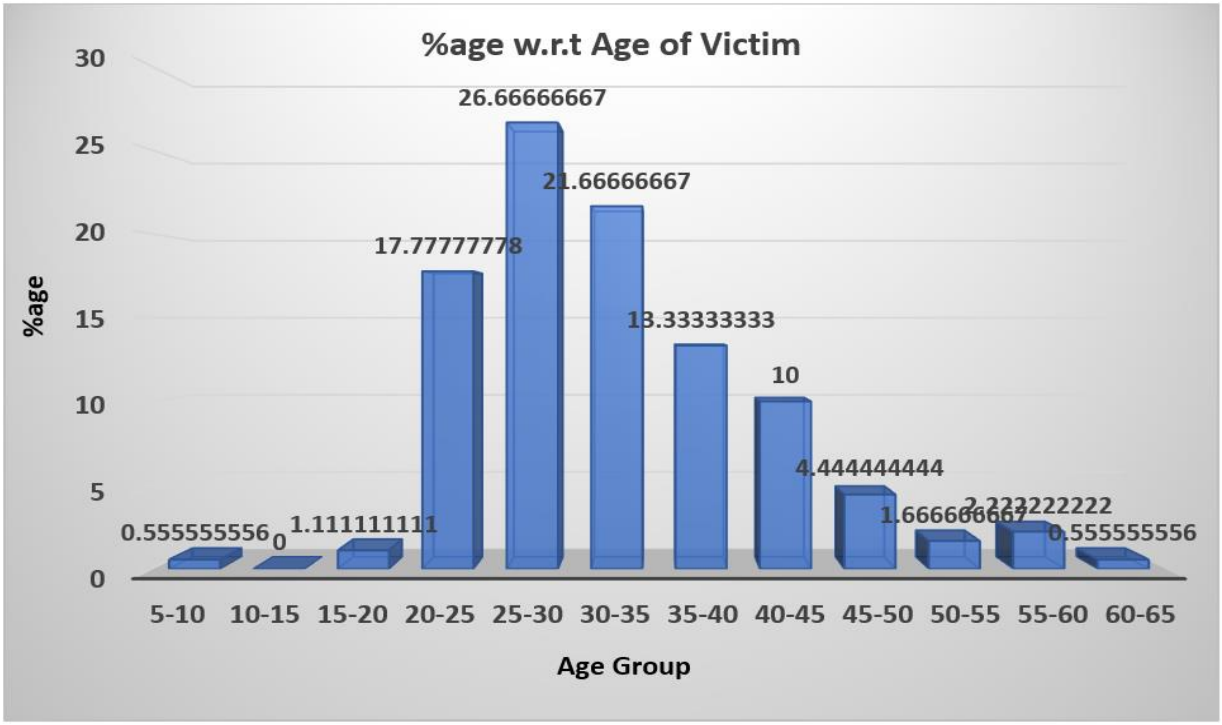
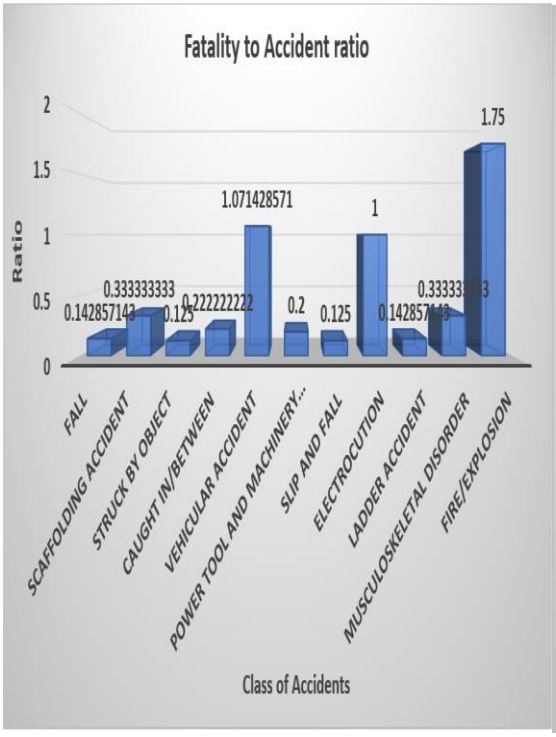


Fig.19

In the fig(19) shown above it can be easily seen that the maximum %age of victims of the safety situations are the persons of age group of 25-30 years which shows how bad consequences this worse safety situation is generating for the economy and hence society.



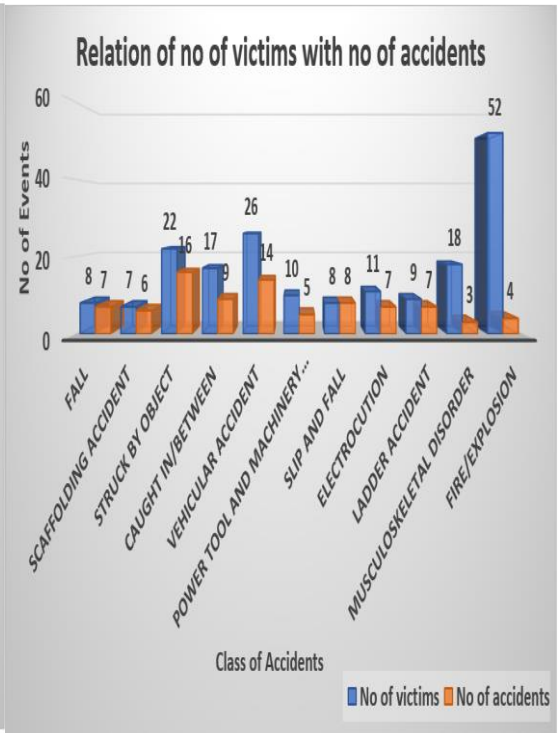


Fig.20 **Fig.21**

In the fig (20) it can be seen that the fatality to accident ratio is highest for the class fire/explosion while the class with second highest ratio is the vehicular accident in which the cause of accident was the malfunctioning or improper handling.

In the fig (21) the graph shows that the highest no of victims are for the class fire/explosion so from the graphical representation it can be envisaged that the class fire/explosion is the most vulnerable class of accident which may occur on a site of such sort.

Summary of Data			
Classification of Accident	No of Accidents	Cost Incurred	Percentages of Cost Incurred
Fall	7	962500	2.197548791
Scaffolding Accident	6	1066000	2.433856635
Struck by Object	16	3281600	7.492442715
Caught in/between	9	3293000	7.518470826
Vehicular Accident	14	23680000	54.06540818
Power tool and machinery accident	5	615400	1.405061326
Slip and fall	8	2671200	6.098797227
Electrocution	7	3305000	7.545868837
Ladder Accident	7	705600	1.611003041
Musculoskeletal Disorder (Repeatitive motion injuries,Sunstroke, Respiratory issues)	3	461500	1.053681836
Fire/Explosion	4	3757000	8.577860581
	86	43798800	100

Fig.22

Above is the summary of the data collected on site and extracted afterwards from the questionnaires. The summary shows the classes of accidents, their number of accidents and cost incurred in each accident. It is to be mentioned that these all accidents are major accidents, and these are not the all accidents which occurred on project site.

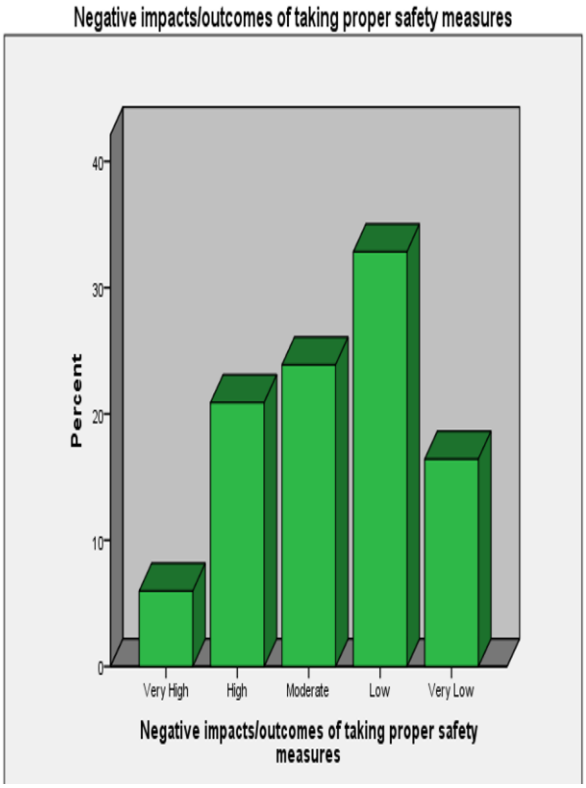
The direct cost incurred is approximately **43.7 million Rs** despite of non-provision of insurance to any construction worker accept the Engineers. Secondly the compensations paid in case of loss of any body part are too low and lastly most of the treatments provided to the injured ones were in the Government hospitals.

SPSS

The data was further processed in the SPSS and certain results were identified.

1. Reliability checks were performed on it.
2. Cron-Bach Alphas test was also performed
3. Shapiro Wilk tests were also performed.

4. The reliability came out to be 0.79 which lies in acceptable range.
5. 3-d graphs were also made.



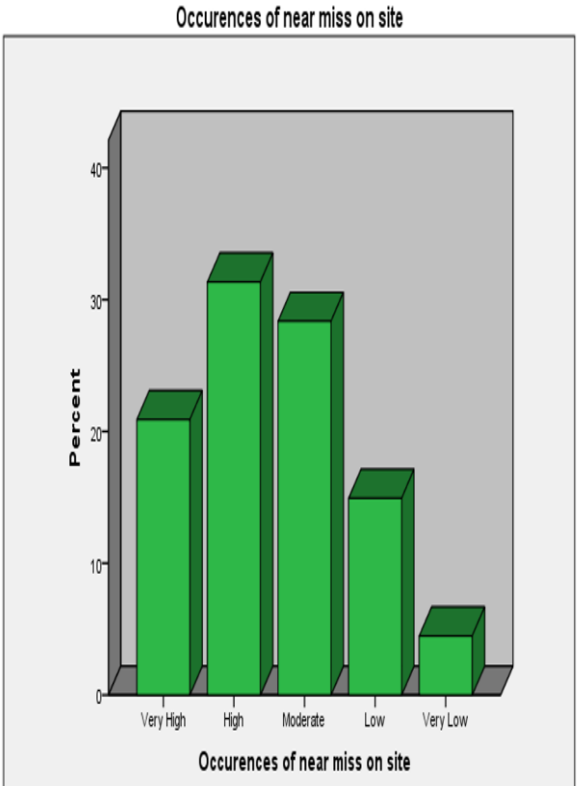


Fig.23 **Fig.24**

Following are some statements which were taken by us during the surveys and are to be highlighted as these took us to some conclusions for our study.

‘’We are directed to increase productivity with minimum use of resources.’’ (Foreman at site)

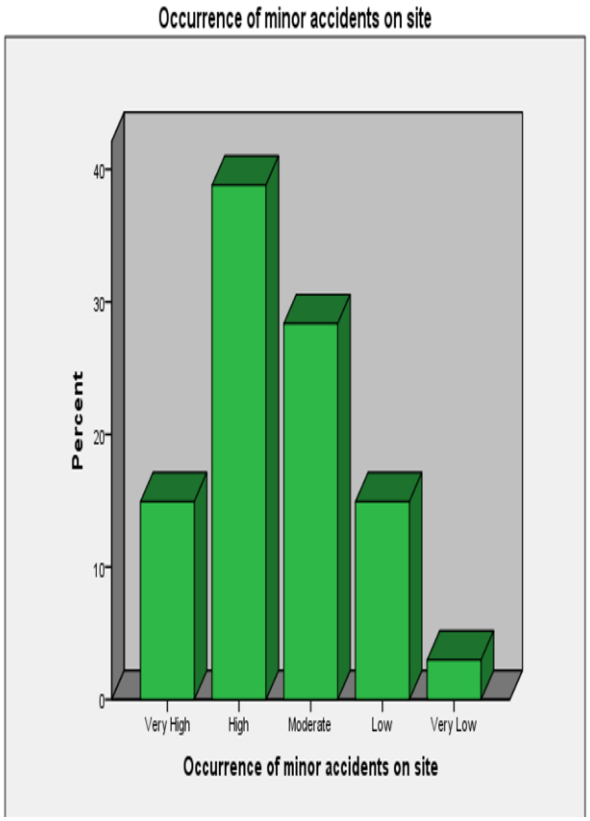
The above statement was given by a foreman working on orange line Lahore site under the National contractor. Further he also stated that to take performance and work rate of desire we have to agree with labourers will like most of the time they don’t agree to use PPE.

This can also be justified from the above fig (23) in which more than 50% of the construction workers said that the negative impact of taking proper safety measures and use of PPE is high.

‘’Chinese contractor fines workers for each safety rules violation and on each same violation the fine gets doubled.’’ (Site Engineer)

Results extracted from the data also showed that maximum of the site accidents were involved with the National contractors and there were very minimum accidents in which the International (Chinese) contractor was involved and one of some reasons for that was the contractor used to fine its workers for each safety violation which gets **doubled** on each repetition.

So, it was one of some major reasons of site accidents that the employer didn’t imposed any penalty/ fine on any safety violation at site (National contractor) as shown in below.



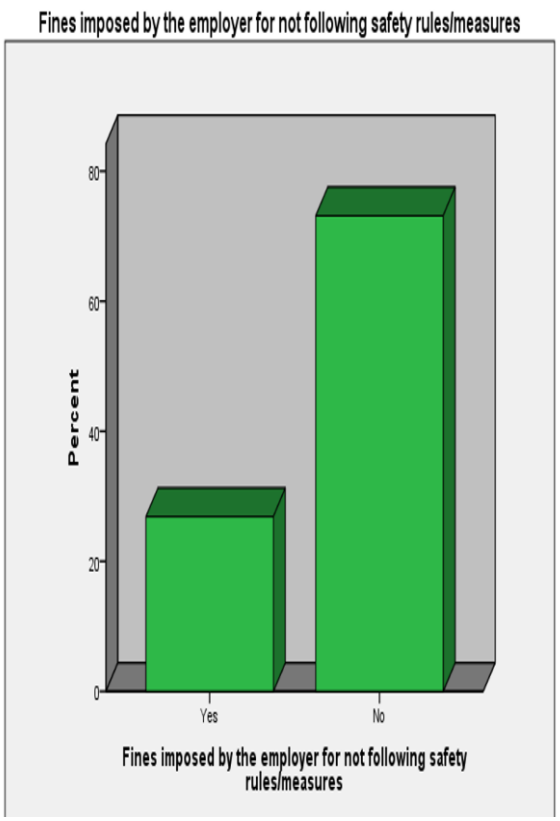
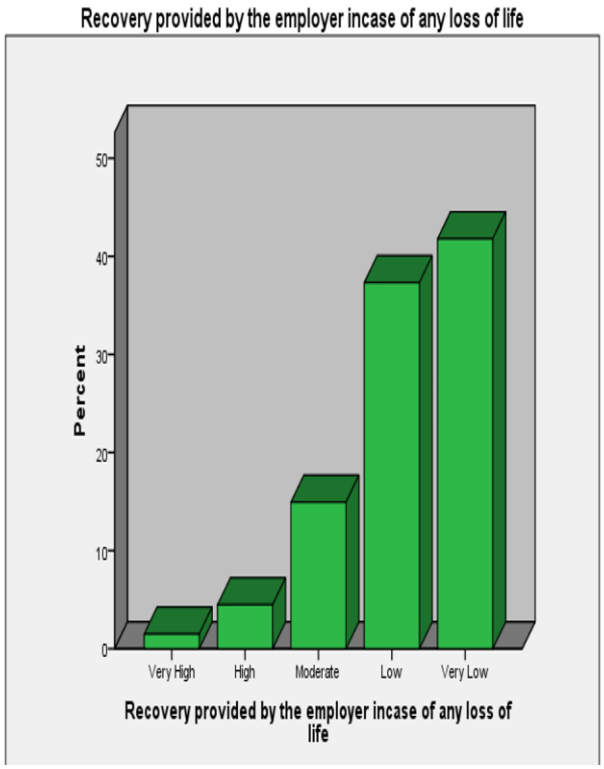


Fig.25 **Fig.26**

The fig(26) is the converse of fig(25). The regime in fig (26) shows that the provision of insurance to the workers is extremely low and that is one of the causes of the higher rate of near misses and injuries at site.



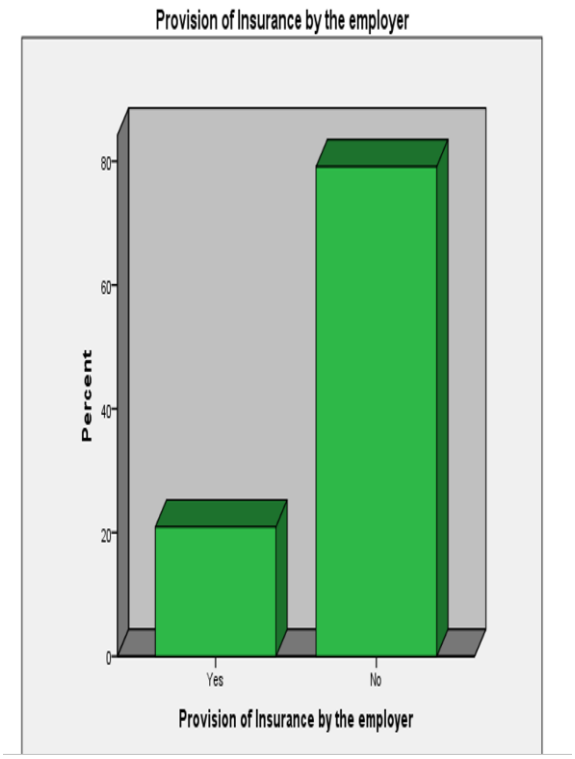


Fig.27 **Fig.28**

Ranking of Classes on basis of risk

The basic requirement of this step is to identify the most probable and most severe class of accident. The need for this strategy is to mitigate the cause by investing upon the remedies. This will help the contractor to invest against the identified class of accidents which have a huge impact on the project budget eventually decreasing the expenditures and the number of casualties due to it. Basically, this strategy will pave an easy path for the contractor to ensure site safety by taking proper measures against the most probable and severe class of accidents i.e. falls, vehicular accidents etc, which in turn will affect the project budget by decreasing the expenditures due to casualties.

Firstly, identify the number of classes of accidents and calculate their probability by dividing no of accidents in the class to total no of accidents taken into account through surveys. Then calculate the severity of class of accidents by dividing the budget loss due to a class to the total budget loss due to all accidents surveyed. Multiply the severity and probability of a particular class and similarly calculate for all classes.

Rank the final magnitude i.e. products of severity and probability of all classes in descending order. This will give an insight to the contractor to invest against the class which has a higher magnitude than others. It shows that the most probable and most severe class of accidents has the greatest magnitude and should be mitigated first.

Class of Accident	No of Accident	Probability factor	Deaths	Injuries	Severity factor	Risk
Fall	7	3	1	7	1	3
Scaffolding Accident	6	2	2	6	3	6
Struck by Object	15	5	2	21	4	20
Caught in/between	9	3	2	16	4	12
Vehicular Accident	14	5	15	25	5	25
Power tool and machinery accide	5	2	1	9	1	2
Slip and fall	8	3	1	7	1	3
Electrocution	7	3	7	10	5	15
Ladder Accident	7	3	1	8	1	3
Musculoskeletal Disorder	3	1	1	17	2	2
Fire/Explosion	4	2	7	51	5	10

Probabilityfactor assigning table

No of acci	Probability	Factor
1-3	Very low	1
4-6	Low	2
7-9	Medium	3
10-12	High	4
12-15	Very high	5

Severity factor assigning table

Casualties		Severity	Factor
Deaths	Injuries		
1	<10	Very low	1
1	>10	Low	2
2	<10	Medium	3
2	>10	High	4
>2	1 or above	Very High	5

Fig.29

Investment plan for different safety measures due to different causes

This step is performed to devise an investment plan to take preventive measures against different sorts of accidents belonging to different classes by determining the root cause of such safety situations.

Classification of accidents

Firstly, the classes of accidents were identified which is already done in the first part. Then the multiple causes of those accidents in a particular class were identified. Then the total loss due to a particular ground was calculated.

Calculation of cost incurred in each accident

Percentage cost of a particular cause within a specific class was also calculated by dividing with the total direct cost determined from the data of accidents.

Identification of safety measures

Then the safety measures to mitigate those causes within a specific class were identified with the help of journals/research papers.

Ranking of safety measures

After identification of the concerned safety measures, it was noted that the number of classes of accidents that were being improved by a single safety measure. Moreover, the percentage cost of the causes in all the classes improved by a single safety measure were added. Thus, the ranking of the safety measures was done with the help of it which gives an insight as to invest in the top ranked safety measure to mitigate the maximum loss.

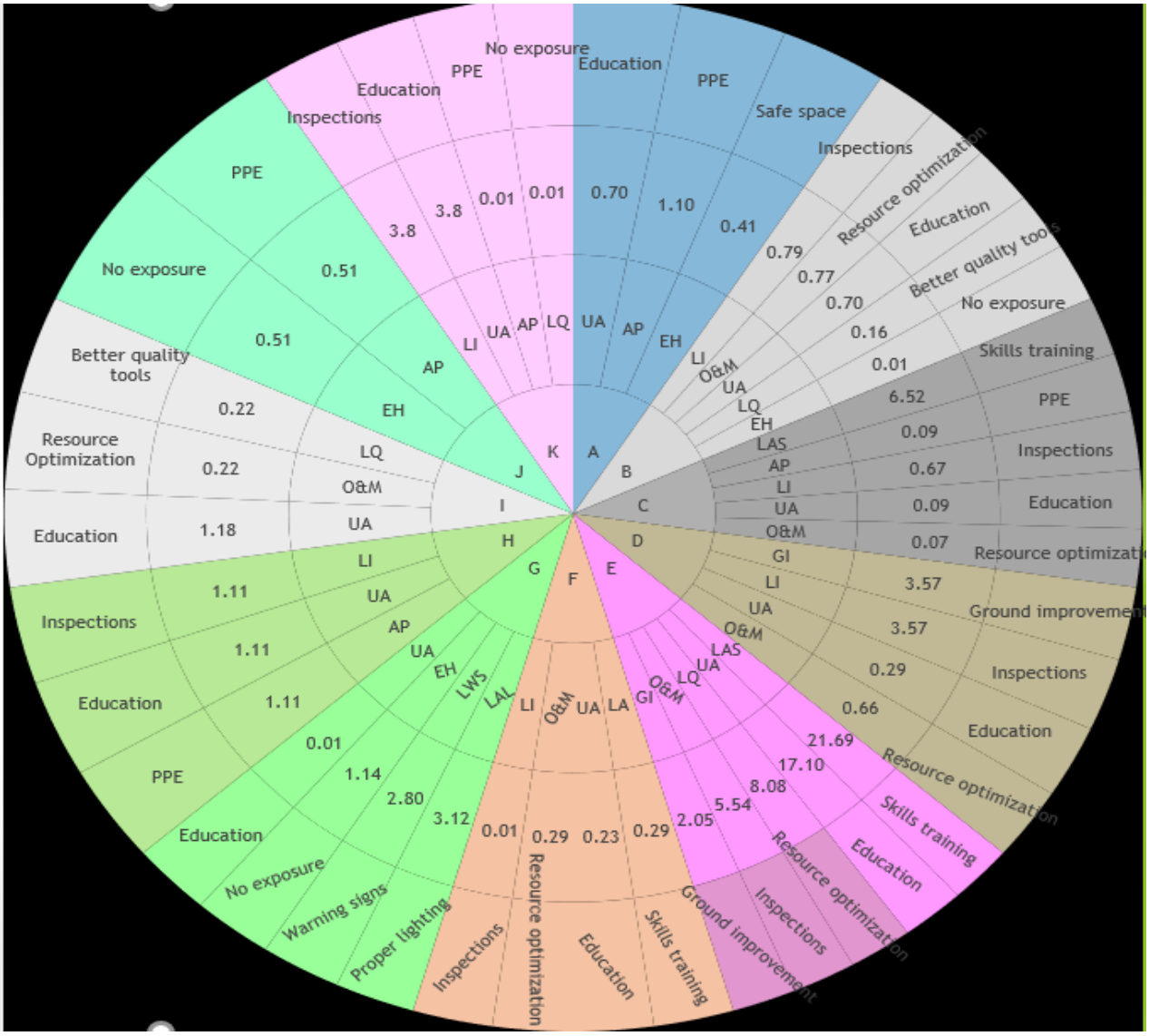


Fig.30

ACRONYM	CAUSE
UA	Unsafe attitude
AP	Absence of proper PPE
EH	Environmental Hazard
LI	Lack of Inspection
O&M	Overloading&Misuse of tools/equipment
LQ	Low quality of tool/equipment
LAS	Lack of adequate skills
GI	Geotech issues
LAL	Lack of adequate skills
LWS	Lack of warning sign

Fig.31

LETTER	CLASS/TYPE
A	Fall
B	Scaffolding Accident
C	Struck by Object
D	Caught in/between
E	Vehicular Accident
F	Power tool and machinery accident
G	Slip and fall
H	Electrocution
I	Ladder Accident
J	Musculoskeletal Disorder
K	Fire/Explosion

Fig.32

Comparative case study

Lucknow Metro Train Project

Orange Line Train (Lahore) and Lucknow Metro Train have some comparative elements in them as these both had the same purpose and also the construction also started on parallel months. Some of the details of it are as follows:

Technical Details

- Lucknow metro is a rapid transit train system.
- Construction started in September 2014 and completed in November 2017
- Total track length of 21km.
- Total no of stations is 20.
- The scheduled cost allocated for the project was USD$2biilion.
- No of cars incorporated are 75.
- Track gauge is 1435mm.
- It is electrically operated with 25kv supply.
- The average running speed is approximately 33-40 kmph.
- Each train has length of 4 cars.

Operational Details

- Started its operation in November 2017
- Approximate daily ridership is round about 68000
- Operated by Lucknow Metro Rail Corporation

www.lmrcl.com

Data Regarding the Site Safety

According to the limited data collected by using internet following are the findings

- No of major/fatal accidents occurred approximately are 5
- No of deceased persons are 2
- No people injured are 25.

www.indianexpress.com

Though the data above is very limited but was also out of our scope that's why we were able to gather a very chunk of information regarding site safety for the Lucknow Metro Train Project.

The information regarding the site safety mentioned above is an inquisitiveness and beacon for the successors to conduct research on it to uncover the ground reality and compare it with our case study which is the OLMT and determine in essence why the death toll and injury rate in case of Lucknow Metro Train was as much low when the conditions are approximately same.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The main objective of this project was to determine the effect of poor site safety on cost of mega project which we did and determined the direct cost as round about **43.7 million Rs.** After determination of the cost for each class of accident we resolute the root causes. Based on our findings we made a framework by following which such sort of site accidents could be avoided and hence a tremendous human life loss which is actually priceless and after that the loss of finance and time could have been avoided.

The framework is shown in the Sunburst chart of fig (30), (31) and (32). The framework is made by the ranking of the causes of accidents based on severity of accidents in terms of loss e.g. accident causing loss of life is highest in its severity.

After obtaining the severity factor followed by the probability of the accident we determined the **risk of the accident** which is the product of the accident probability and the severity factor. The class of accident with higher risk is ranked higher in the ranking chart, for example the class vehicular accident is ranked highest in the ranking as 25. So that means whenever a project of such kind takes place the contractor should invest highest investment to insure safety in the class having the highest ranking in risk ranking chart. In case of OLMT the class demanding the highest safety investment is the **Vehicular accidents**.

Limitations

- Data is collected for just one transit mega project in Pakistan.

- Only direct cost of accidents was quantified. In order to narrow down scope, indirect cost of accidents such as tools damage, loss of productivity, time lost etc was not quantified.
- Probability of occurring of an accident after providing a safety measure cannot be predicted.

Recommendations

- Indirect costs of accidents occurred.
- Model of layers/Tiers of safety measures to almost nullify probability of accidents.
- Cost of different safety measures or layers of safety measures.
- Orange Line Lahore and Lucknow Metro Train were somewhat competitors as both started on close dates and had to be completed as so. There should be a comparison that what were the differences in the safety conditions of both projects when both the countries have similar sort of workforce behavior.
- There was a huge death toll due to the poor site safety conditions on OLMT, how it can be reduced.

CHAPTER 6

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Appendix 1

Questionnaire Form for Final Year Project

Title :

Cost overrun due to lack of construction site safety, A case study of Orange Line Metro (Lahore)

C1. Introduction

Name : _____ **نام:**

Designation: _____ **عہدہ:**

Experience: _____ **تجربہ:**

Age: _____ **عمر:**

Working Site: _____ **سائٹ:**

Homeland: _____ **آبائی شہر:**

Working Duration: _____ **مدت:**

Previous Similar Experience: _____ **سابقہ تجربہ:**

C2.

Do you have knowledge about any accident at site:

کیا آپ سائٹ پر کسی بھی حادثے کے بارے میں معلومات حاصل کرتے ہیں؟

1. Accident: _____ حادثہ:
   Location: _____ جائے وقوع:
   Reason: _____ حادثے کا سبب:
   Deaths & Injuries: _____ زخم/اموات:
   Payment to deceased: _____ برجانہ برائے میّت:
   Medical expenditure incurred: _____ برجانہ برائے زخمی:
2. Accident: _____ حادثہ:
   Location: _____ جائے وقوع:
   Reason: _____ حادثے کا سبب:
   Deaths & Injuries: _____ زخم/اموات:
   Payment to deceased: _____ برجانہ برائے میّت:
   Medical expenditure incurred: _____ برجانہ برائے زخمی:
3. Accident: _____ حادثہ:
   Location: _____ جائے وقوع:
   Reason: _____ حادثے کا سبب:
   Deaths & Injuries: _____ زخم/اموات:
   Payment to deceased: _____ برجانہ برائے میّت:
   Medical expenditure incurred: _____ برجانہ برائے زخمی:

C3. Problems related to safety at construction site.

1) Provision of Safety helmet(PPE). (Yes/No)
   حفاظتی ہیلمٹ کی فراہمی
2) Availability of Safety gloves(PPE). (Yes/No)
   حفاظتی دستانے کی دستیابی
3) Provision of Face protection(PPE). (Yes/No)
   چہرے کے ماسک کی دستیابی
4) Provision of respiratory protection(PPE). (Yes/No)
   سانس کے ماسک کی دستیابی
5) Provision of first aid in case of any accident(PPE). (Yes/No)
   حادثے کی صورت میں ابتدائی طبّی امداد کی فراہمی
6) Emphasis by the employer on taking safety measures(PPE). (Yes/No)
   حفاظتی اقدامات لینے پر آجر کی طرف سے زور
7) Organization of workshops regarding site safety(PPE). (Yes/No)
   حفاظتی اقدامات پر ورکشاپ کی تنظیم
8) Fines imposed by employer for not following safety rules(PPE). (Yes/No)
   حفاظتی اقدامات نہ لینے پرآجرکی طرف سےعائد کردہ جرمانہ
9) Health issues due to absence of any safety equipment:
   حفاظتی اقدامات کی غیر موجودگی کی وجہ سے صحت کے مسائل
   1)_____
   2) _____
   3)_____

Alphabets	Equal to	
A	Very High	بہت زیادہ
B	High	زیادہ
C	Moderate	مناسب
D	Low	کم
E	Very Low	بہت کم

C4. Issues of labour originated due to lack of safety measures

Occurrences of near miss. (A, B, C, D, E)
قریب کی یاد کے مواقع

Occurrences of minor accidents. (A, B, C, D, E)
معمولی حادثات کے مواقع

Accidents causing permanent loss of any body part (A, B, C, D, E)
حادثات، کسی بھی جسم کے حصہ کے نقصان کا سبب بنتا ہے

Loss of lives in site accidents. (A, B, C, D, E)
سائٹ کے حادثوں میں انسانوں کی زندگی کا خاتمے

Health issues due to absence of any safety equipment. (A, B, C, D, E)
کسی بھی حفاظت کا سامان کی عدم موجودگی کی وجہ سے صحت کے مسائل

Positive impact of taking proper safety measures. (A, B, C, D, E)
مناسب حفاظتی اقدامات لینے کے مثبت اثر

Fig.11

Questionnaire form for Final Year Project

Title :

Cost overrun due to lack of construction site safety, A case study of Orange Line Metro (Lahore)

Note: For Contractor and its staff (Other than labourer)

C1. Introduction

Name : _____ **نام:**

Designation: _____ **عہدہ:**

Qualification: _____ **اہلیت:**

Experience: _____ **تجربہ:**

Age: _____ **عمر:**

Working Area: _____ **سائٹ:**

Working Duration: _____ **دورانیہ ملازمت:**

Previous Similar Experience: _____ **سابقہ تجربہ:**

C2. Problems related to construction site safety

1. Approximately how many safety situations have been occurred since the project has started on this site?

پروجیکٹ کے آغاز سے اب تک تقریباً کتنی بارحفاظتی اقدامات اٹھانے کا امکان پیدا ہوا؟

_____

_____

2. With whom those accidents were related to (Labour or else), also tell about the compensation actually paid?

جن حادثات کی وجہ سے حفاظتی اقدامات لئے گئے ان میں کون ملوث تھا (لیبر/ انجنیئر/ دیگر)؟

تلافی کرنے کے لئے ہرجانہ کتنا دیا گیا؟

_____

_____

_____

_____

3. How much worth those loses had

نقصانات کی لاگت کتنی تھی؟

_____

_____

_____

4. How badly those incidents affected the site progress in terms of cost and time

حادثات کوسٹ اور ٹائم کے لہٰذ سے کس طرح سائٹ پرکیے گئے کام کے تسلسل پر اثر انداز ہوئے؟

_____

_____

_____

5. How much compensation do you pay a minorly injured construction worker?

معمولی زخمی مزدور کو کتنا ہرجانہ دیتے ہیں؟

_____

6. How much compensation do you really pay to a majorly injured worker?

شدید زخمی مزدور کو کتنا ہرجانہ دیتے ہیں؟

_____

7. How much compensation do you really pay to a deceased labour (if any)

آپ مرحوم مزدور کے لواحقین کو کتنا ہرجانہ دیتے ہیں؟

_____

8. Problems usually encountered while ensuring the safety at site

سائٹ پر حفاظت کو یقینی بنانے کے دوران عام طور پر کن مسائل کا سامنا کرنا پڑتا ہے؟

_____

_____

_____

9. Consultant's prominence about site safety

سائٹ پر حفاظت کے بارے میں کنسلٹنٹ اپنی اہمیّت کتنی واضح کرتا ہے؟

_____

_____

10. Is there any provision of safety clause in the Construction contract

معاہدہ میں کسی بھی حفاظتی شق کی فراہمی ہے؟

_____

_____

11. Time delay due to construction site accident (if any)

سائٹ پر حادثے کی وجہ سے وقت کی تاخیر (اگر کوئی ہے)؟

_____

_____

12. Comment any other issue/problem regarding site safety (if any)

سائٹ پر حفاظت کے بارے میں کسی بھی دوسرے مسئلے /مسئلہ کو تبصرہ کریں (اگر کوئی ہو)

_____

_____

_____

Safety acts at the above-mentioned working site (Review by our side):

_____

_____

_____

Fig.12