Achieving Excellence in Construction Safety: A Study of Indian Scenario

THESIS
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By
NIKHILESH BANERJEE

Under the Supervision
of Dr. V.B.DESHPANDE
Prof. Emeritus, IIT Delhi

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BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE
PILANI, RAJASTHAN

CERTIFICATE

This is to certify that the thesis entitled **Achieving Excellence in Construction Safety : A Study of Indian Scenario** and submitted by **NIKHILESH BANERJEE** ID No. 2000 PHXF406 for award of Ph.D. Degree of the Institute, embodies original work done by him under my supervision.

Signature in full of the Supervisor : V.B. Deshpande

Name in capital block letters : **Dr. V.B. Deshpande**

Designation : Prof. Emeritus,
Dept. of Civil Engineering,
IIT Delhi

Date: 16/12/05

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ABSTRACT

Construction is regarded as the most hazardous industry. Unless the hazards are identified and controlled they might result in Accidents / Injuries.

A construction accident generally causes injury to people, damage to property and / or disruption to the work process. All these outcomes affect the bottom line of an organization. Hence the need for a research in Construction Safety.

The present study attempts to analyze the status of construction safety performance in India by considering five different types of issues, viz, Technological, Organizational, Behavioural, Performance Monitoring and Measurement and Implementation issues. For this purpose a questionnaire survey has been conducted.

The survey response data is analyzed for their (i) Mode, (ii) Correlation & (iii) Regression against three criteria for safety performance measurement, namely Frequency Rate of Lost Time Accident (FRLTA), Frequency Rate of Recordable Incidence (FRRI) and Severity Rate of Lost Time Accident (SRLTA).

SPSS-11 Software is used for the above analysis. The Study identifies a set of issues (under the five different categories noted above), which are perceived to the most important for accident prevention, and issues having significant correlation with FRLTA, FRRI & SRLTA are also highlighted

The study also identifies and recommends a Linear Regression Model of SRLTA with all the issues analyzed separately. Similar regression model is also obtained for SRLTA with all the issues taken together.

Finally the study recommends a Safety Assurance Model based on Severity Rate of LTA using OHSAS – 18001: 1999 and ISO 9001: 2000 as a tool for safety performance improvement.

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ABBREVIATIONS, ACRONYMS

BBS	:	Behaviour Based Safety
BLS	:	Bureau of Labour Statistics
FRLTA	:	Frequency Rate of Lost Time Accidents
FRRI	:	Frequency rate of Recordable Incidences
HSE	:	Health, Safety and Environment
INR	:	Indian Rupees
ISO	:	International Organization for Standardization
MSDS	:	Material Safety Data Sheet
OGP	:	Oil & Gas Producers
OHSAS	:	Occupational Health and Safety Assessment Series
OSHA	:	Occupational Safety & Health Administration
SPSS	:	Statistical Package for Social Sciences
SRLTA	:	Severity Rate of Lost Time Accidents

CHAPTER – 1

INTRODUCTION

1.0 Introduction

In general perception Safety implies freedom from danger, harm and risk. In the light of this perception construction is considered as one of the most hazardous activity all over the world, more particularly in developing countries (Sohail 1999, Abdelhamid and Everett 2000, Vaid 2000). Of the total workforce in US, construction's share is only 5% but it contributes to 20% of all occupational fatalities and 9% of all disabling occupational injuries (Accident 1997). The corresponding figure in 1994 was 14% and 9% respectively (Accident 1994). It is clear from the above that during the above noted period US Construction industry witnessed a 6% rise in fatalities though the disabling injury rate remained the same at 9% of all industries put together. The construction scenario, therefore, remains a matter of concern. Everett and Frank Jr. (1996) reported that the above figures though declined from the corresponding figures in mid-1980s, injuries and fatalities in construction sites are still a problem.

Juran Somavia, Director General, International Labour Organisation (ILO) in his presentation entitled "Decent Work, Safe Work"(ILO Safe work 2000) observed, "The right to life is the most fundamental right. Yet every year 1.2 million men and women are deprived of that right by occupational accidents and work related diseases." He further adds that " Fatality rates in some European Countries are twice as high as in some others, and in parts of Middle East and

Asia fatality rates soar to four-fold to those to in the industrialized countries with the best records."

A study by ILO on 'Global Programme on Safety, Health and Environment' (ILO Safe work 2000) highlights:

- Every year more than two million people die of work related accidents and diseases.
- More than 160 million people fall ill due to work place hazards.
- The poorest, least protected- often women, children and migrants are also amongst the most affected.
- Micro and small enterprises account for over 90% of enterprises whose condition are very poor and the workers in these are often excluded from all labour protection.

The above study indicates estimate from the United States, United Kingdom, Germany and Norway and put the direct cost of accidents to billions of dollars. It further points out that "In many developing countries the death rates among workers are five to six times those in the industrialized countries. Yet the phenomenon is still largely undocumented and there is insufficient political will to address them."

Pandita (2001) in his article entitled, "India- Health and Safety At Work" observed, " About 75% of the global workforce lives and works in Third world Countries which have so many serious problems like poverty and unemployment that the status of health and safety is very low." The article also highlights the fact that workforce in the South Asian Region (Bangladesh, India, Nepal, Pakistan, Sri Lanka) represents 20% of the worlds working population. Despite having rich natural resources, these countries economic growth rate is slow. Pandita further observes, "Industrialization in South Asia focusses on production, health and safety attains a low priority."

Many researchers on construction safety have highlighted the hazardous nature of construction activity. To cite some examples the following may be referred:

Whitelaw (2001), based on the statistics from UK's Health and Safety Executive (HSE) points out that UK's construction workers are approximately five times more likely to experience fatality and two times more likely to be seriously injured as compared to average of all industries put together. Similarly Khartam (1997) indicates that US construction workers are three times more likely to be killed than the all-industry average and one in six construction worker can expect to be injured every year. Everett and Frank (1996) feel that the problem of accidents and injuries in construction is beyond control. According to them many contractors appears to be immune to the moral, ethical and social consequences of occupational injuries and fatalities. Mc Donald and Hrymak (2002) in a report to the Health and Safety Authority Dublin & the Health and Safety Executive, Northern Ireland highlighted the fact that the culture in the construction industry is generally not conducive health and safety. Similar views are expressed by Blockley (1995) in his observation that construction is better known for its poor safety culture and improvement of safety performance cannot be achieved unless the culture is also improved.

The hazardous nature of construction activity causes accidents resulting into fatalities or other injuries and / or property damage. All these outcomes have a cost implication to the construction process. Attempts have been made by various agencies to estimate the cost of accidents and injuries to the construction industry. In USA an organization called Business Roundtable (BR) consisting of 200 executives of major corporations was established in 1972(Everett and Frank 1996). These Executives meet to focus and initiate action on a number of public issues. A study by BR in 1979 indicated that accidents cost $8.9 billion which is equivalent to 6.5% of the $137 billion dollar (1979) spent annually on construction of industrial, utility and commercial enterprises (Report A -3, 1992).

As compared to US, a UK study estimates cost of occupational accidents and ill-health in construction sector inclusive of cost of delay, absenteeism, health and insurance costs amongst others account for 8.5% of project cost (EASHW 2004).

According to a survey report in Hong Kong the total number of days lost due to accident during a twelve-month period is 165730. This loss of days cost HK$140 million. This does not include various costs of medical expenses, delays in project completion, administrative time spent on investigation and reporting of accidents, etc.

The above background justifies the need for an analytical study and research on safety performance excellence in the construction sector in India. This has become increasingly important on the face of WTO and Globalization .The problem needs to be tackled in its proper perspective in order to acquire and sustain a competitive edge in the global market place.

1.1 Excellence in Construction Safety

The impact of an accident in a construction site embodies one or more of the following:

- Injury to People.
- Damage to Property, and
- Disruption of the process

We have seen in the foregoing paragraphs the losses arising out of accidents. Construction safety excellence should, therefore, start with prevention of accidents resulting in avoidance of losses. Any journey to an excellence programme commences with the perception of the term 'Excellence' so that a set of action plan can be conceived.

The term 'Excellence' is understood to be of outstanding merit /quality (Waite, 1994). Going by this meaning / perception safety excellence would require an outstanding control / prevention of accidents in construction sites.

The current research deals with managerial issues associated with the effectiveness of accident prevention as a precursor to the achievement of excellence in construction safety in India.

1.2 Objectives Of The Study

The objectives of the study are as follows:

- To identify the various issues associated with the accident prevention in construction sites.
- To evolve the criterion for safety performance measurement.
- To determine the various technological issues affecting construction safety performance.
- To find out the different organizational issues affecting construction safety performance.
- To determine the various behavioral issues affecting construction safety performance.

- To establish the various performance monitoring and measurement issues impacting construction safety performance.
- To identify the significant implementation issues affecting construction safety performance.
- To evolve significant ingredients of the combined effect of all the above issues impacting construction safety performance.
- To suggest an empirical model for some of the criteria of construction safety performance in the Indian context.

1.3 Organization Of the Thesis

This thesis is organized in eight chapters as described below:

Chapter 1 deals with the background of construction safety, describes the importance and need for a safety excellence programme and also provides the organization of the thesis.

Chapter 2 deals with a comprehensive review of available literature on construction safety performance. This chapter consists of three parts, viz., part -1 details the issues associated with construction safety performance, part - 2 highlights the various criteria for measurement of construction safety performance and part - 3 contains 'Behaviour Based Safety' as a tool for improvement of construction safety performance.

Chapter 3 describes the current scenario in construction. This chapter is organized in two parts. The first part deals with the construction scenario in developed countries like UK, USA, Canada, Australia and the second part deals with that in the developing countries like, Singapore, Honking, Philippines and India.

This chapter also deals with the review of existing Safety excellence models.

Chapter 4 deals with the methodology for data collection, survey questionnaire design, selection of samples for exploring the ongoing practices of safety management in Indian construction industry and describes the method for analysis of data.

Chapter 5 contains analysis of data related to Technological, organizational and behavioural issues and describes the results of the analysis highlighting the critical factors for achieving excellence in safety performance in Indian construction sector.

Chapter 6 deals with analysis of data pertaining to performance monitoring and measurement and also analyses data on implementation issues along with the results of analysis.

Chapter 7 studies the impact of safety issues (as a combination of all the above issues) on construction safety performance.

Chapter 8 summarizes the conclusion and indicates the limitation and scope for further research.

The list of references, survey questionnaire for data collection, annexure and authors CV are appended at the end.

CHAPTER-2

LITERATURE REVIEW

2.0 Introduction

In the first chapter the background of safety in construction has been highlighted. As can be seen from the observations of various researchers, it appears reasonable to assume that construction is a hazardous process anywhere in the world. The outcome of safety performance at sites may, therefore, give rise to loss of life, injury, illness of persons involved in the construction activities besides being a contributor to property damage.

To overcome the situation it is necessary to install an effective accident prevention programme at construction sites in order to achieve safety excellence.

As a first step in developing an accident prevention programme any researcher would aim at identifying the issues that influences the safety performance at sites followed by evolution of criteria for performance measurement. The next obvious step will involve Performance improvement measures through leading indicators of at –risk behaviour of workmen through Behavioural Safety Approach. This in turn will provide a path forward for achieving safety excellence.

2.1 Construction Safety Performance Issues

We are aware that the term Excellence means 'a great merit'. Going by this meaning we would be able to appreciate that Safety Performance Excellence implies that a great job is done in effective safety implementation as a precursor to accident prevention. Many researchers strongly advocated the need for a supporting culture while commencing the journey to performance excellence (Low and Chan 1998; Beckhard and Harris 1987;Griffis 1992). It is widely accepted that an unsafe condition or unsafe act or a combination of both give rise to an accident. Whereas Management is responsible for the unsafe condition(s) prevailing in the work place (liability clause), it is the worker who may indulge in an unsafe act and land into an accident. Question arises as to why our workers may sometime demonstrate behaviour that he commits an unsafe act? The reasons may be multiple in numbers. In a construction site the behaviour is dependent on the organizational culture. Edwin and Raymond (2003) observed that different researchers have defined 'Culture' in various connotations and quotes the definitions given by some of them as follows:

i) "The collective programming of the mind which distinguishes the members of one human group from others, Culture in this sense, includes systems of values and values are the building blocks of culture".

ii) "Culture of a society is its shared values, understandings, assumptions and goals learned from earlier generation. It results in common attitudes, codes of conduct and expectations that guide behaviour".

iii) "Culture describes the social system created by a group of people, it starts from the moment a few people get together regularly and begin to establish norms and rules through which they will interact and communicate with each other and maintain order, it is about patterns of meaning, it is about shared beliefs, values, perspectives and worldviews. It is about shared behaviour, practices, rules and rituals; it is not limited to groupings by race or ethnicity, but can describe a sub-culture within a society – designers for instance; it is often associated with language and communication; it is viewed as a mental or cognitive construct created in the mind of the people; it is learned; it can be found in materials, objects, artifacts, clothing, art work, and so forth; and it can emanate from social institutions and structure, such as governments, economies and legal systems, as well as geographic and environmental factors".

From an overview of these concepts of culture it is noted that researchers have one thing in common about the perception of culture and that is the shared values, belief and group, mental or cognitive construct makes the culture and culture gets manifested in the behaviour. In the context of accident prevention, if the workmen group has a strong belief about the organization goal of zero accident, the same will be reflected in their work behaviour.

Culture exhibits the style of functioning of an organization. In the parlance of Safety management, three distinct style of management are observed (Pascal,1997) viz:

- **SWAMP** : Safety without Any Management Process (16% of all companies).
- **NORM** : The Naturally occurring Reactive Management (77% of all companies), also called the 'Reluctant compliers'.
- **WORLD CLASS** : Leaders amongst industry, where everybody desires to reach (7% of all companies). The characteristic determinants of the three styles are as per table 2.1 below.

Table 2.1: Comparison of Characteristics of the three different Safety Management Styles.

Sl.No.	STYLES → / ↓ CHARACTERISTICS	THE SWAMP STYLE	THE NORM STYLE	WORLD CLASS
1	Safety Responsibility	Not recognized or rejected.	Not understood or defined	Line management owned/ driven
2	How it is perceived	As a burden	As a cost	As a good business investment
3	Management Practices	- Accidents do happen. - Autocratic Style. - Safety next to production. - Planning minimal, short time. - Communication one way (down the line). - Solution: make do/ make shift. - Minimal employee involvement. - Adversarial climate.	- Accidents are excused away. - Recognizes problem (unwilling / unable to solve). - Willing to go halfway. - High visibility (many labels, little result). - Significant line/ staff authority conflict. - Programme/ campaign short-lived. - Line accountability lacking.	- Accidents are intolerable. - Safety is an element of management effectiveness. - Responsibilities and expectations are clearly defined. - Employees are empowered, rewarded. - Communication informal, open. - Efforts closely measured and responded to.

Source: Quality, Safety and Environment – Synergy in the 21st Century; Pascal, D. (1997)

There is not a single issue, which alone can be considered as the most important one to impact the safety performance at construction sites. Larry. L. Hansen (2000) in his paper 'The Architecture of Safety Excellence' observes, "Safety excellence is not the result of a singular strategy. One cannot cite generic solutions or universal answers because no one best way exists". Larry's observation is based on 'the law of the TANOB WAY'- a universal recognition that "There Aren't No One Best Way" (Andre).

In fact there are a variety of issues prevailing upon the construction sites depending upon the nature of construction, location of site and demography of the workmen involved. Researchers have identified different issues to be more crucial for safety performance and thus affect the excellent performance criteria. The following cases justifies the point:

Smallwood (2000) observed that poor contractor performance was primarily due to:

- Lack of concern for the work environment
- Poor management of design activities
- Delayed information
- Inadequate planning, and
- Low skills of workers.

The above issues were accepted by other researchers like Allens (1994); Henry (1994) & Lobelo (1996) who had further identified the issues affecting safety performance as noted below:

- Cost over run.
- Delayed completion.
- Rework (unacceptable quality).
- High accident rate.
- Insensitivity to environmental considerations.
- Poor work practices, and
- Adversarial relationships.

Dlungwana et al. (2000) opined that contractor's poor performance can be attributed to the failure on the part of the contractor to appreciate the importance of some of the key issues like integration of design and construction process as well as quality management process which seriously affects the construction safety performance.

Construction projects involve a number of stakeholders such as, Client, Contractor/General contractor (GC), Specialty contractor /sub contractor (SC). In a study sponsored by Construction Industry Institute (CII) of USA an attempt was made to identify the speciality contractor's practices which contribute most significantly to the health and welfare of workers (Hinze and Gambatese 2003). The study revealed that on a large project subcontractor safety performance was affected to a great extent by the actions of General Contractor/ Construction Management firm. The study also indicates the following issues affecting subcontractor safety for large Projects:

(i) Quality of Scheduling.

(ii) Co-ordination effort of General Contractor / Construction Management firm.

(iii) Level of emphasis on safety as placed by G.C/ C.M. (Hinze & Gambatese, 2003).

It was further observed in the study that superior safety performance was achieved when the G.C. or C.M.:

(i) Provided a full- time safety Director.

(ii) Discussed safety in coordination meetings and pre-job conferences,

(iii) Monitored project safety performance

(iv) Insisted on total compliance with safety regulations, and

(v) Had top Management involvement in project safety.

Many researchers are of the opinion that General Contractors or Construction Management Firms play a pivotal role in the safety performance of their subcontractors (Hinze & Tally 1988; Hinze& Figone 1988; Hinze 1997).

Another issue affecting safety performance is the employee turn over rate It was noted in a study sponsored by Construction Industry institute (CII) of USA (to identify the best practices of organizations in pursuance of the goal of Zero accident) that increase in turn over rate of employees resulted in increase of injury rate (Hinze & Gambatese 2003).

Turnover of employers require organization to have new hires on board. New hires are generally found to be the most susceptible to accidents/ injuries (Hinze 1997). This requires greater attention of management for the safety of new hires (Hinze 1978, 1990). Balasubramaniam and Louvar (2002) in a study on major accidents & lessons learnt pointed out that there are some problems with the government databases.

There are various other issues associated with poor safety performance (Lee & Halpin, 2003) such as:

- Inadequate task planning.
- Poor safety training
- Lack of safety incentives and
- Insufficient incident investigation.

Prezioski (1989) stresses the fact that unsafe acts are the major issues in construction accidents. Prezioski (1989) observed that unsafe acts are the main factor in 50% of construction accidents and a contributing factor in respect of 85% of construction accidents.

Barrie and Paulson (1992) attributed the poor safety performance due to

(i) Physical issues (unsafe condition at the workplace) and

(ii) Behavioural issues leading to unsafe acts by workers

Toole, (2002) observed that all construction accidents take place due to one or more of the following eight root-causes:

(a) Lack of proper training.
(b) Deficient enforcement of safety
(c) Safe equipment not provided
(d) Unsafe methods of sequencing the tasks.
(e) Unsafe site conditions.
(f) Safety equipment provided but not being used
(g) Poor attitude towards safety
(h) Isolated, sudden deviation from prescribed behaviour

Of the above eight causes first five i.e. (a) to (e) give rise to unsafe conditions and the last three i.e. (f), (g) & (h) are due to unsafe acts by the task performers.

(ii) The Accident Root Causes Tracing Model (ARTCM) propagated by Abdelhamid & Everett (2000) recommend the following three root causes of accidents:

(a) Failing to identify an unsafe condition that existed before an activity was commenced or developed after an activity was started.

(b) Deciding to proceed with a work activity after the worker identifies an existing unsafe conditions and

(c) Deciding to act unsafe regardless of initial condition of the work environment.

(iii) A study on Evaluation of Safety Measures in Construction Industry in Hong Kong by a team comprising Ahmed, S.M., Tang, Pi Asher, SI and Ahmed, I., pointed out that the ARCTM model suggested above underscores possible contribution of management and labour towards safety. They further suggests that the domain of management and labour contribution to accident process falls within the characteristics of an organization and advocates for the following six key aspects identified by Dawson, S. (1992 - Analyzing Organizations), which contribute to the Safety Management Plan of an Organization (Ahmed, et. al.):

(a) People aspects - Lack of training, knowledge discipline and motivation, poor attitude, inconsistent behaviour, lack of intrinsic motivation, unwillingness approach to work and lack of awareness about safety are the manifestation of people aspects.

(b) Strategy aspects - Lack of commitment, planning and review. These aspects are linked to organizations vision & mission. Safety being a core issue shall be given top priority while setting goals and objectives for a particular project.

c) Technology aspects- Introduction of new technology helps us in construction methods & techniques for higher productivity. However, adequate training of workers is crucial for ensuring safety while introducing new technology.

d) Environment aspects- Changes in environment (internal & external) influences the organization greatly. While internal environment can be controlled, the external environment requires great attention to react. With the advent of new techniques and concepts, organizations are required to act as proactively as possible in order to sustain their operation.

(e) Structural aspects - These include the problems of lack of planning, instruction, inspection, maintenance and control. Bureaucratic set up of organization requires central control. In many cases accidents occur as a result of lack of actions to resolve the problem in a timely manner.

(f) Cultural aspects - Lack of discipline, disregard to recommended safety and work practices, inadequate response to actively pursue the benchmark practices start out of an organization culture and can play havoc in just fulfilling the contractual requirement rather than a total improvement in safety & quality

A close review of our construction sites present scenario and safety performance status will perhaps indicate that most of the above issues are quite prevalent in our sites as well. This may, however, be examined by the various construction organizations, desirous of adopting a safety improvement strategy as a means to enhance their competitive advantage for setting the path forward.

Helmreich & Merrit (1998) indicated that safety and quality of tasks performed by workers are affected by their:

- Professional competence
- Skills

- Attitude to & perception of the job
- Organization & Management

Other issues affecting safety performance include

1. Management Commitment (Cohen 1977).
2. Employee attitude (Shroder, 1970, Ojanen, 1988).
3. Safety Perception of employees (Williamson et. al, 1997, Glundemund 2000)

Cheyne et. al (1998) recommends the following five safety climate factors as safety activity antecedents:

(i) Safety Management

(ii) Communication.

(iii) Individual Responsibility

(iv) Safety Standards and Goals, and

(v) Personal Involvement

Researchers are also of the opinion that reliability of complex work systems in achieving operational goals safely depends on 'social structures' and 'technical arrangements' (Mearns, et.al 2003). It is further observed that the role of social and organizational issues played in the etiology of accidents is quite significant (Sheen, 1987, Cullen 1990, OECD Nuclear Agency 1987, Vaughn 1996). Vaid (2000) also pointed out the extreme importance of technological, organizational & behavioural issues in achieving safety excellence in the Indian construction context.

Safety performance issues remain incomplete unless studies of Cohen et. al (1975) and Smith, et. al (1975) are referred to. These studies had brought in focus the following significant issues:

- Presence of High-ranking Safety Officers had resulted in the lower accident rate.
- Presence of Senior Managers with involvement of safety activities helped in achieving lower accident rates.
- Training of new employees with re-training of existing employees also resulted in lower accident rates.
- Informal communication between higher management and workers also significantly influenced the accident rate.

In another study by Shannon, et. al.(1996) it is indicated that the characteristic features of organizations with lower rate of Lost Time Injuries include:

- Managers perceptions of workers participation in the decision making process.
- More harmonious Manager –Worker relations.
- Encouragement for long-term career commitments.
- Inclusion of health and safety responsibilities in Managers job description
- Performance appraisals related to health and safety.
- Frequent participation of Health and safety Managers in health and safety meetings.

A summary of the major issues and their categorization is depicted in Table 2.2.

Table- 2.2: Construction Safety Performance Issues and their Categorization

Sl.No.	Issue Description	Reference	Categorization
1	Supporting Culture	Low & Chan (1998) Beckham & Harris (1987), Griffis (1992)	Behavioural
2	Actions of General Construction (GC) affect safety in large projects.	Hinze & Tally 1988), (Hinze & Gambatese (2003), Hinze (1997)	Implementation
3	Quality of scheduling	Hinze & Figone (1988)	Organizational
4	Emphasis on safety by General Contractor (GC) or Construction Management Firm (CM)	Hinze & Gambatese (2003)	Organizational
5	Deployment of full-time Project Safety Director	- Do -	Performance Mon. & Meas
6	Monitoring of Project Safety Performance	- Do -	Implementation
7	Insisting for total compliance to Safety Regulation	- Do -	Organizational
8	Top Management Commitment to Project Safety	Cohen (1997), Hinze & Gambatese(2003)	Behavioural
9	Employee Turnover rate	Hinze & Gambatese (2003)	Organizational
10	Inadequate Task Planning	Lee & Halpin (2003) Small wood (2000) Allens (1994), Henry (1994) & Labelo (1996)	Organizational
11	Poor Safety Training	- Do –	Organizational
12	Lack of Safety Incentives	- Do -	Organizational
13	Insufficient Incident Investigation	Lee & Halpin (2003)	Implementation
14	Unsafe Act of Workers	Preziosky (1989)	Behavioural
15	Physical issues like unsafe condition	Barrie & Paulson (1992)	Technological

S.NO.	Issue Description	Reference Categorization	
16	Behavioural issues leading to unsafe act by workers	Barrie & Paulson (1992)	Behavioural
17	Professional competence and skills	Small Wood (2000) Dlungwana (2000) Shroder 1970, O'janen, et.al(1988)	Organizational
18	Attitude to and Perception of the job by workers	Helmreich & Merrit (1998)	Behavioural
19	Workers Organization and Management	Helmreich & Merrit (1998) Cheyne et. Al (1998)	Behavioural
20	Safety Management (style)	-Do-, Pascal1997)	-Do-
21	Communication	-Do-	Implementation
22	Individual Responsibility	-DO-	Organizational
23	Safety Standards & Goals	-DO-	Implementation
24	Personal Involvement	Smallwood (2000)	Behavioural
25	Lack of concern for the work environment	- Do -	- Do -
26	Poor Management of Design Activities	- Do -	Implementation
27	Delayed Information	Allens (1994)	Organizational
28	Cost Overrun	Henry (1994)	- Do -
29	Delayed Completion	Labelo (1996)	- Do -
30	Rework (Unacceptable quality)	-Do-	Performance Monitoring& Measurement
31	High Accident Rate	- Do -	-Do-
32	Poor Work Practices & Adversarial Relationship	-Do-	-Do-

2.2 Criteria for Safety Performance Measurement

There is a common saying "What gets measured, gets done". In the parlance of construction, safety performance measurement is essential for initiating any improvement programme. Raouf & Dhillon (1994) highlights the fact that safety is concerned with prevention of accidents and elimination/ control of hazards at the workplace. Accident prevention is, therefore, an important step towards performance measurement.

Safety performance criteria describes 'what to measure' type of questions. Measurement may be considered as a process of assignment of numerals to objects or events according to rules (Stevens, 1959). When selecting the criterion for safety performance measurement it is important to carefully consider the definitions of desired performance adopted for the purpose. Various characteristics are associated with the performance criteria.

Following are the nine characteristics of a good measurement technique as suggested by Tarrants (1980):

(i) Quantifiable Criterion.

(ii) A constant unit of measurement for the entire range to be evaluated.

(iii) Sensitive measurement technique.

(iv) Capable of duplication with the same results obtained from the same items measured.

(v) Adaptability in the range of characteristics under evaluation.

(vi) Inclusion of validity of Measurement.

(vii) Error-free results.

(viii) Efficient and understandable

(ix) Administrative feasibility.

Raouf & Dhillon (1994) observed that there are three types of Contemporary Safety Measurement Indices as follows:

- American National Standard Institute (ANSI) document ANSI – Z16.1
- Bureau of Labour Statistics (BLS)/ Occupational Safety and Health Act (OSHA), and
- Occupational Injury and Illness Statistics.

The ANSI system cited above dowels upon the frequency rate and severity rate pertaining to fatality, disabling injuries (lost time). ANSI measures pertain to the relative frequency of occurrence of major injuries and their impact (days lost or charged to these accidents).

The Disabling Injury Frequency Rate (DIFR) is defined as the total number of disabling injuries (including illness) per million employee hours worked.

Thus:

$$\text{DIFR} = \frac{\text{No. of disabling injuries}}{\text{No. of employee hours worked}} \times 10^6$$

Similarly Disabling Injury Severity Rate (DISR) is defined as the number of days lost or charged per million employee hours worked, i.e.

$$\text{DISR} = \frac{\text{No. of days lost (charged)}}{\text{No. of employee hours worked}} \times 10^6$$

The BLS – OSHA system of measurement is used in U.S.A. for nationwide survey of work injuries and illnesses so as to provide nationwide statistics on an industry basis for all recordable occupational injuries and illnesses taking place in the work sites (Refer to Figure 2.3). The measurement is termed as 'OSHA – Incidence Rate (IR_{OSHA}) and is defined as

$$IR_{OSHA} = \frac{\text{No. of recordable injuries}}{\text{No. of employee hours worked}} \times 200{,}000$$

In the OSHA incidence rate formula the multiplier 200,000 is arrived at by considering 100 full-time employees working at 40 hours per week for 50 weeks in a year.

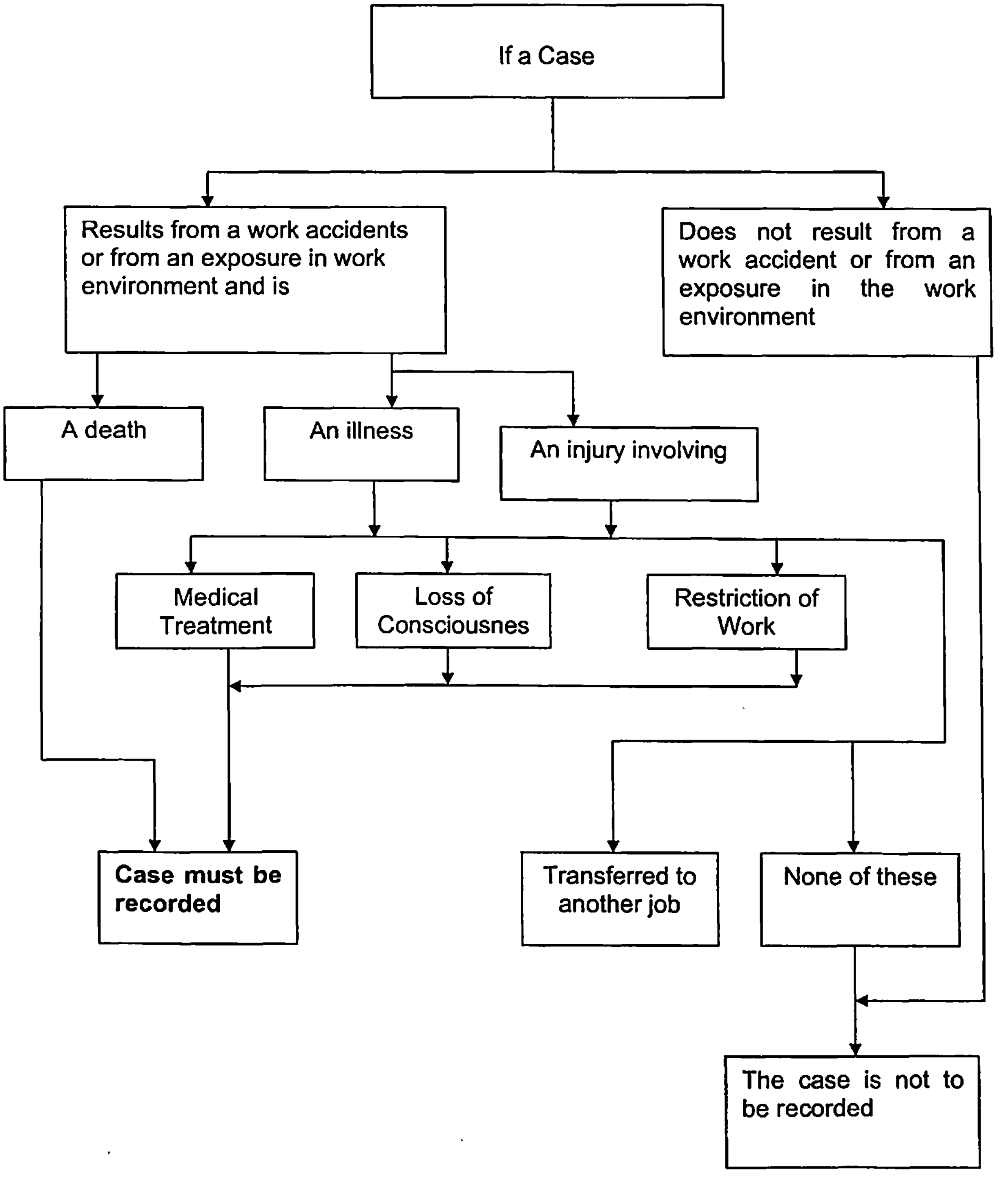
The Occupational Injury and Illness Frequency Rates and Severity Rates are defined as:

$$\text{Frequency Rate} = \frac{\text{No. of lost time injuries}}{\text{No. of employee hours worked}} \times 200{,}000$$

$$\text{Severity Rate} = \frac{\text{No. of days lost}}{\text{No. of employee hours worked}} \times 200{,}000$$

The above measures of Safety Performance relates to the practices in U.S. Bureau of Labour Statistics of U.S.A. acknowledges the important role played by accident statistics (BLS 1997).

Figure – 2.3 : Guide to Recordability of cases under OHSA



Source: Safety Assessment : A Quantitative Approach (Raouf & Dhillon 1994)

In India the criteria for safety performance is based on Frequency Rate and Severity Rate and is similar to the one described above with the exception that the multiplier 200,000 in the definition of Frequency Rate and Severity Rate is replaced by 10^6 or one million.

Thus in Indian context the measure of injury/ accident statistics is given by:

$$\text{Frequency Rate} = \frac{\text{No. of lost time injuries}}{\text{No. of employee hours worked}} \times 10^6$$

$$\text{Severity Rate} = \frac{\text{No. of days lost}}{\text{No. of employee hours worked}} \times 10^6$$

The injury statistics also called the lagging indicators are considered as measures of failures (HSE 2001). There is no single reliable measure of safety performance. It therefore relies on up-stream (pro-active) measures based on prevention approach such as number of training courses organized or number of inspection performed. Identification of at-risk behaviour of workmen through Behaviour based safety is also considered as a leading indicator of safety measure since it provides an opportunity to arrest the hazard before it can cause an accident. All said and done there is no widely accepted method of replacing the frequency rate of OSHA recordable injuries and illnesses ((Harvey 2002).

2.3. Performance Improvement Through Behaviour Based Safety (BBS)

BBS programme was introduced in 1930s by H.W. Heinrich. Heinrich's research on thousands of insurance and injury /illness reports from the corporate supervisors blamed the workmen behaviour as responsible for the injuries/illness (SEMCOSH). BBS technique applies the principles of behavioural sciences for performance measurement in safety management. The principle involves sampling, recording and publishing the percentage safe (versus unsafe) behaviours noted by observers drawn from the workforce and management, specially trained. This gives more data on potential system and individual failures than can be obtained from a study of accident reports (Holt 2001).

In the U.K., University of Manchester Institute of Science and Technology (UMIST) have extensive experience of applying BBS approach to construction industry. Similarly, in the U.S.A. the work done by Dr. Thomas Krause and his team at the Behavioural Sciences Technology, Inc., California is well known (Holt 2001). Dr. Allan St. John Halt in his book "Principles of Construction Safety" observes that: "Employers investing in this techniques say they have found that the involvement of workers in the measuring process generates interest and improved commitment to the employers safety objectives. The results are said to be significant in that the techniques lead to a reduction of loss producing incidents as well as to the improved assessment of performance by the positive step of workers safe action"

2.3.1 The Working Principles of BBS

The fundamental premise on which Behaviour Based Safety (BBS) rests is the belief that accidents are the outcome of unsafe act(s) of the workers. The belief is not beyond doubt. As we have noted in the earlier part of this chapter, accidents are caused by unsafe acts, or unsafe condition or both. It is, therefore, not correct to say that by implementing BBS alone in the construction activities, probability of accidents happening can be eliminated. Accident prevention can better be achieved through a two-pronged approach, viz., management behaviour & actions (demonstrating commitment & support) to eliminate workplace hazards arising out of unsafe conditions and BBS approach to attain a goal directed behaviour of workers towards maintaining the desired safety culture.

2.3.2 Implementation of BBS in Construction

Implementing BBS concepts in construction sites is a proactive approach to accident prevention by way of voluntary participation and empowerment of the workers. The steps involved in BBS implementation include the following :

i) Identify safety-related behaviors those are critical to excellent performance.

ii) Gathering workgroups safety excellence data

iii) Providing ongoing two-way performances feedback, and

iv) Removing systems barriers to continual improvement

The BBS philosophy implementation requires identifying a team of workmen and supervisors who are provided training in the principles of BBS. The training module comprises various aspects related to:

i) Behaviour observation skills in order to identify safety at-risk behaviour and also safe behaviours.

ii) Measuring safety performance for alignment of the safe behaviours vis-à-vis organizational goals

iii) Action plan for continuous improvement

iv) Issues in implementation

v) Introducing the concepts to a site

vi) Roles & Responsibilities

With the trained people the behaviour observation process is initiated. Observation serves the following purposes:

i) Helps in identifying desirable behaviours in workers,

ii) Correlating the undesirable behaviours, and

iii) Provides data for future analysis.

Data from the observations are collected, compiled and analysed for establishing trends. These trends may indicate behaviour that require additional emphasis / training to improve safety performance. The critical behaviours identified needs systematic management for improvement of safety performance. For this purpose, certain 'benchmarked' behaviours are identified by the team consisting of workers, supervisors and managers. These benchmarked practices are employed as management tools within the organization for the purpose of workers self management, training, information processing, performance evaluation, corrective action, etc. and effect the desired behaviour change (ECT). Performance measurements based on 'downstream' measures like the accident frequency rate, severity rate, etc. are not as effective indices as compared to 'upstream' measures like the work practices and behaviours (complying to safety norms or not) in bringing about a 'behavioural change'. This is because of the fact that:

i) Upstream measures are comparable to the process parameters in a manufacturing / construction industry and can be better controlled by the process approach.

ii) At-risk task related behaviours are the final common pathway for almost all incidents.

iii) At-risk behaviours common at a site are supported somehow by the culture of the site.

Moreover, upstream measures provide reliable indices of safety risks and are the targets of BBS intervention (FMCSA) "As a result of changes in upstream indices (safety-related behaviour), the downstream outcome (accident severity / frequency rates) will automatically change".

The observation data is obtained by employees observing each other and through their observation they give one to one feedback/coaching/guidance regarding safety related behaviours. For an effective outcome BBS depends heavily on the employees training in the BBS approach and strong management support.

The following approach adopted by Idaho National Engineering & Environment Laboratory (INEEL) for implementation of BBS practices may act as a path forward to many construction organizations for their implementation of BBS programme (INEEL):

- Develop a plan for implementation
- Solicit for a worker implementation group

- Identify "Critical" behaviours
- Prepare a check list of such critical behaviours
- Train workers on HOW TO OBSERVE
- Distribute the check list to workers for gathering observed data
- Compile data and determine the % safe behaviours
- Develop a corrective action plan for "At –Risk" behaviours and put the plan into action.

Better success for implementation may be achieved by adhering to following common theme in best practices in the 'DOE Behavior –Based Safety best Practices Workshop' (DOE Workshop):

- Train everybody within the target organization engaged in the BBS process.
- Focus on engaging workers, union leaders, supervisors & managers to start with to develop the process as 'bottom-up'.
- Obtain management support by educating them to take a long-term view to BBS.
- Endeavour to achieve a contact rate of 1.0, i.e., every employee should be contacted each month for an observation.
- In case BBS cannot be implemented broadly, focus to be made to high-risk operations.
- Make the implementation process as interesting and fun as possible.

There are organizations that have successfully implemented the BBS philosophy and reaped benefits out of it. To name a few, Du-Pont Ltd., KCI Constructors Inc., an affiliate of Kellogg Brown & Root adopted BBS model of Behavioural Science Technologies while working in EXXON Baytown Olefins

Project Expansion, Texas, Koch Refining Company, etc. As a success story one can refer to the simple step-by-step approach followed sequentially by Koch Refining as highlighted below:

i) Define relevant target behaviours to increase or decrease frequency.

ii) Observe target behaviours during a base line phase and set specific goals for achievement

iii) Intervene to improve the target behaviours, and

iv) Test the impact of the intervention by continuing to observe the target behaviours.

The above literature review suggests a number of issues, which are considered as significant for overall safety performance improvement. However these may be the perceptions of individual researchers since there is no evidence of significance of the issues in controlling the safety performance measure. The review also identifies the traditional measurement criteria and lastly describes the BBS approach in accident prevention these findings are based on studies /researches conducted overseas. The prevailing literature on construction in India does not provide any input showing that significant research has been done in this area. International journals whatever are available cannot be implemented as it is in India due to several reasons like, socio- economic culture, employees awareness and attitude to safety, work practices in use and behavioural factors. Moreover the extents of importance of these issues with safety performance measure are not established. This is one of the major gaps in the prevailing literature. Need is felt to address the issues vis-a vis the safety performance measures for prevention of work place accidents and achieving performance excellence in construction safety in India. The present study chalks out a path forward for safety performance improvement by establishing the significant relatedness of the issue variables with the performance criteria.

From the above literature review the following issues become apparent :

(i) Earlier researchers indicated a variety of issues which are important for the construction safety performance, but none of them suggested the combined effort of the issues on safety performance.

(ii) The method and means to monitor the issues for a better safety performance is not clear from the literature review.

These are the basic inputs to the formulation of the present problem. Additional inputs are also derived from a review of current status and existing models.

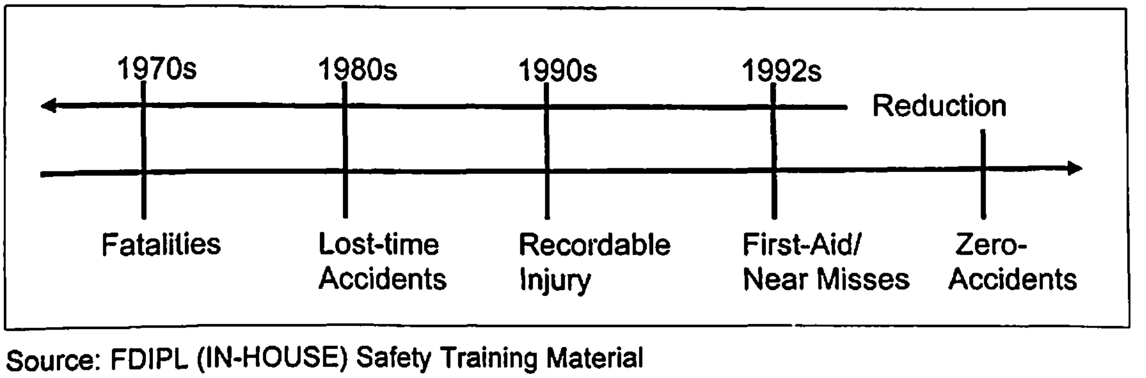
CHAPTER – 3

CURRENT STATUS AND REVIEW OF IMPORTANT MODELS

3.0 Introduction

The various Nations are now appreciating construction safety as an agenda for improvement. Many countries have developed their own standards and legislation for controlling the hazards associated with the construction process. There has been a shift in the strategy for performance monitoring and measurement with regard to construction safety. Safety performance measures used to be based on safety statistics with regard to Frequency Rate & Severity Rate Fatality during the 1970s. The same has evolved through various stages/ including lost time accidents, Recordable injury; First Aid/ Near misses to the present day 'Zero-accident philosophy' (FD 1997) adopted by World Class Construction Companies. The 'Safety Time Line' shown in fig.3.1 describes the above evolution of safety performance measurement, which is critical for achieving excellence in safety.

Fig- 3.1 : Safety Time Line



Source: FDIPL (IN-HOUSE) Safety Training Material

The Safety Time Line refers to the lagging indicators of Accident/ Injury Statistics. This is in line with our observations in Chapter-2 (Para 2.3) regarding the common practice of measuring safety performance based on the outcome measures at the end of the job, in spite of its limitations and criticisms.

3.1 Current Scenario of Safety Performance

The general performance record of construction safety is very poor. According to Business Round table survey the Bureau of Labour Statistics of U.S. Government highlighted that for every $10 crore of construction cost there is one fatality and 167 injuries (Report A-3, 1982).

A report from Centre to Protect Workers Rights indicates that fatality in U.S. construction industries in U.S. is very much higher than that in Sweden, the Netherlands, Ontario and Canada. This is evidenced from the fact that since 1970, fatality rates in construction have been reduced by 75% in Sweden. The same is the fact with Ontario where fatality rate in construction has been reduced by 83% since 1965 (CPWR 1993). Various researches carried out across different parts of the world provide information with regard to safety performance data. These data helps us to compare the performance of different regions of the globe. Some of these information are highlighted below:

(I) The International Association of Oil & Gas Producers report No. 353 (OGP 2004) furnishes safety performance of global E & P Industry in 2003. Some important performance results for 7 regions are quoted hereunder:

Table – 3.1 : Safety Performance Results of Global E & P Industry in 2003 (Region-wise) (Based on OGP Report No. 353, 2004)

Region	Safety Performance Results		
	Fatalities	Lost-time Injury Frequency Rate (FRLTA)	Total Recordable Incidence Rate (TRRI)
Africa	42	0.81	2.32
Asia/ Australia	8	0.42	1.89
Europe	4	2.09	6.78
FSU (Former Soviet Union)	10	0.91	2.04
Middle East	16	1.62	6.09
North America	21	0.98	5.39
South America	10	2.22	5.53
Overall		**1.16**	**4.00**

Source : OGP Report No. 353, 2004

A careful look at the above table brings out the following in relation to Exploration & Production (E&P) Industries for the year 2003.

(i) Fatalities are found to be highest in Africa followed by North America, Middle East.

(ii) Europe, Asia/ Australia, FSU and South America are observed to have better performance as far as fatalities are concerned.

(iii) With regard to Frequency Rate of Lost Time Accident (FRLTA), Asia/ Australia is found to be the best followed by Africa, FSU & North America. These regions performance is better than global average of 1.16.

(iv) The FRLTA results of South America, Europe and Middle East are higher than the global average of 1.16.

(v) The results of TRRI shows that the performance of Asia/ Australia is the best followed by FSU and Africa.

(vi) The TRRI record for Europe, Middle East, South America and North America are higher than the global average of 4.0.

As an overall observation, performance of Asia/ Australia region appears to be the best in respect of FRLTA and TRRI.

Similarly, fatalities are lowest in Europe amongst the seven regions as per the OGP Report No. 353 (OGP 2004).

The report on country performance also indicates that out of 74 countries, Papua New Guinea, Singapore and Peru had zero lost time accidents in 2003. These countries reported relatively less work hours.

The other findings of the report indicates that countries in Asia/ Australia, FSU and Northern America regions performance was as per global average (1.16) whereas performance of majority of countries in the European Region are found to be worse than the global average.'

II. The Incidence rates of total Fatal and Accidental injuries in construction in U.K. for the period from 1973 to 1979 is reported (Malhotra 1988) in Table 3.2 as follows:

Table – 3.2 : Incidence Rates of Total and Fatal Accidental Injuries in Construction in the U.K. from 1973 to 1979.

Year	Accidental Injuries (Total)	Fatality (All Construction)
1973	35.4	0.216
1974	34.6	0.160
1975	34.6	0.177
1976	35.3	0.153
1977	33.0	0.131
1978	34.0	0.122
1979	31.0	0.117

Source: Extract from safety legislation in Construction Industry (Malhotra 1988)

Note: (i) Incidence Rates per 1000 workers at risk. Above figures are as per ILO recommendation.

(ii) Incidence rates quoted by HSE, U.K. are over 100000 workers at risk.

(iii) Reportable accidents involve one or more days of lost time.

Vaid (1988) has compiled from various publications of ILO and the available reports from the national governments significant inputs on "Employment and Accidents in Construction Industry in various countries". Data related to some of these countries are extracted and shown in Table 3.3.

Table – 3.3 : Employment and Accident Data in Construction Industry in various Countries.

Sl. No	Country	Year	Total Employment	No. of Accidents	Fatal Accidents	No. of Accidents per 1000 workers
1	U.K.	1982	N.A.	N.A.	1000	-
2	U.S.A.	1983	N.A.	N.A.	N.A.	40.7
3	France	1983	2,01,642	25437	423	137

Sl. No	Country	Year	Total Employment	No. of Accidents	Fatal Accidents	No. of Accidents per 1000 workers
4	GDR	1980	N.A.	N.A.	N.A.	46.2
5	FRG	1983	N.A.	N.A.	N.A.	131.4
6	Hungary	1983	N.A.	N.A.	N.A.	43.3
7	New Zealand	1982	N.A.	4134	15	-
8	Indonesia	1984-85	34,67,929	759	N.A.	11.57
9	Malaysia	1984	N.A.	5829	440	46.4
10	Singapore	1985	80,000	1427	N.A.	-
11	India	1987	35,.60,908	N.A.	N.A.	-
12	Hong Kong	1982	1,02,000	16,909	N.A.	2048

Source : Vaid, K.N. (1988),; 'National Perspective on Safety in Construction (original data compiled from ILO Publication)

The status of safety in construction in U.K. as per Health and Safety Executive (HSE)'s provisional report is indicated in Table – 3.4.

Table – 3.4: Injuries to Employees in UK's Construction Industry : 1996 / 97 to 1999 / 2000.

Sl. No.	Year	Severity of Injury			
		Fatality	Non-Fatal (Major Injury)	Non-Fatal (Over 3 days)	Total
1	1996-97	66	3227	8637	11930
2	1997-98	58	3860	9756	13674
3	1998-99	47	4289	9195	13531
4	1999-00	59	4290	9957	14306

Source : Collated from 'Key-facts injuries in Construction Industries 1996/97-1999/00 Provisional as reported to Health and Safety Executive, U.K.

The above data shows that during the four-year period from 1996-97 to 1999-00, UK's fatality rate has gone down a little, but overall injury rate has increased by 16.6%. The above results require better control of safety performance for achieving excellence in construction.

Workplace health and safety status at Queensland is noted from the Queensland Workplace Health and Safety Strategy Action Plan 2004-2007. The National Safety Performance Data obtained from Comparative Performance Monitoring Report (CPM 5, 2003) indicated that the incidence rate of work related fatalities is 3.3 per 100,000 employees in 2001-02 as against 5.0 in Australia.

In comparison to the performance data of European countries, America, the performance of Queensland appears to be better placed as far as safety in construction is concerned though there is enough scope for improvement to attain the goal of Zero-Accident Philosophy which is the need of the hour.

3.2 Current Scenario in India

As regards safety performance of construction industry in India, the major issue is lack of data in the public domain (Smith 1999, Vaid, 2000). It is observed that the injury rate is quite high in construction in India is as per the estimate that about one out of five persons employed in India suffers in work related injury but only a fraction is generally reported (Vaid, 2000).

Smith (1999) observed the following startling features related to construction safety in India in an attempt to estimate the real number of deaths:

(i) About 1.0 Lac to 1.5 Lac workers are victims of fatality in workplace accidents,

(ii) The occupational illness contracted in a year is about two million!

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(i) About 1.0 Lac to 1.5 Lac workers are victims of fatality in workplace accidents,

(ii) The occupational illness contracted in a year is about two million!

(iii) No attempt was made to calculate the loss due to workplace accidents in terms of life and to the Indian economy. Smith (1999) estimates the loss to GNP to be around US$ 12 billion.

The problem of poor safety performance of Indian Construction Industry has been observed by (Mathur 1988) to be due to the following:

(i) Poverty of Workers	:	Leading to acceptance of any work in spite of the job being risky.
(ii) Casual Employment	:	Causing difficulty in maintaining safe work practices.
(iii) Lack of Awareness of Workers	:	Workers coming from rural areas, most of whom are semi / illiterate and resort to unsafe practices due to lack of awareness.

iv) Fatigue
v) Work Environment
vi) New Technologies
vii) Living Condition of Workers and
viii) Attitude of Management

} All these issues contribute to poor Safety Performance of the workforce

These impediments require proper care during planning and execution of the construction work.

The above scenario gives an idea about the difficulty in determining relative positioning of Indian Construction Industry as compared to Australia, Singapore, Europe, America and Hong Kong. The current scenario identifies the need for performance monitoring and measurement of safety performance of Indian Construction Industry and lack of data and research in this area appears to be a major gap in conducting research achieving safety excellence.

3.3 Review of Some Important Models:

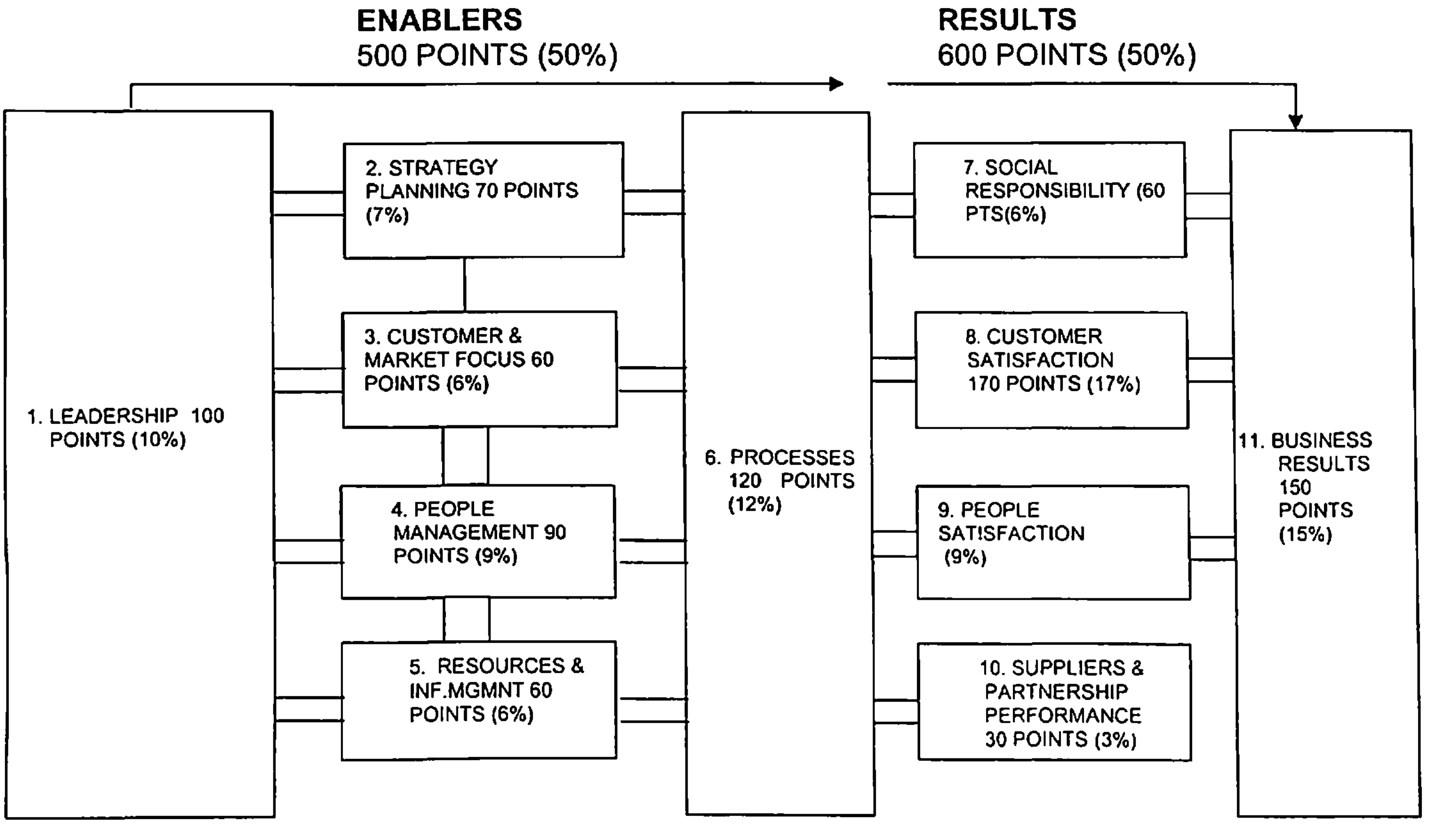
Research in construction safety is generally not found in abundant quantity. However, some countries have conducted such research to facilitate implementation of safety excellence programme. Review of some important amongst them is brought out here.

3.3.1 South African Construction Excellence Model (SACEM)

This model is developed based on South African Excellence Model (SAEM) with a view to promote culture of business performance excellence in construction industry. The structure of the Model is depicted in figure 3.4

The model resembles to the EFQM model of business excellence and consists of 11 performance assessment criteria with 6 of them belonging to the 'Enablers' category and the balance 5 to the 'Results' category as shown in the figure below.

Fig.- 3.2 : Structure of South African Construction Excellence Model



The SACEM STRUCTURE

The activities referred to in the above model have strong inter-linkage such that the activities on the enabler side has a direct impact on the results side of the performance equation.

The business results are measured in respect of organization's achievement of planned business objectives and also its effectiveness in satisfying the needs and expectations of its stakeholders.

Assessment of scores in the SACEM Model:

Against each of the criteria contractors responses are scored on a 0-3 point scale where '0' means activity has not been done or not started and '3' means "fully achieved". The total scores are aggregated out of a total score of 1000. Contractors with scores close to 1000 are well managed and show good results. Areas of improvement as well as strength of contractors are summarized for adopting necessary improvement action.

The SACEM Model is being put to validation for overall industry acceptance (Dlungwana, et. al 2002).

The SACEM Model though developed in line with EFQM Model does not indicate the steps/ processes to be adopted for enhancing the scores of enablers & results (particularly for the results). The Model speaks about a supportive culture, system, approach & tools to achieve performance excellence. The present Model is proposed for overall business excellence and not for specific issues of safety excellence.

Further the Model gives equal emphasis (50%) on enablers business results which are the outcomes of enablers (6 items).. The Model is generalized one and does not provide any relationship of the casual factors (the enablers) with the effects (business results).

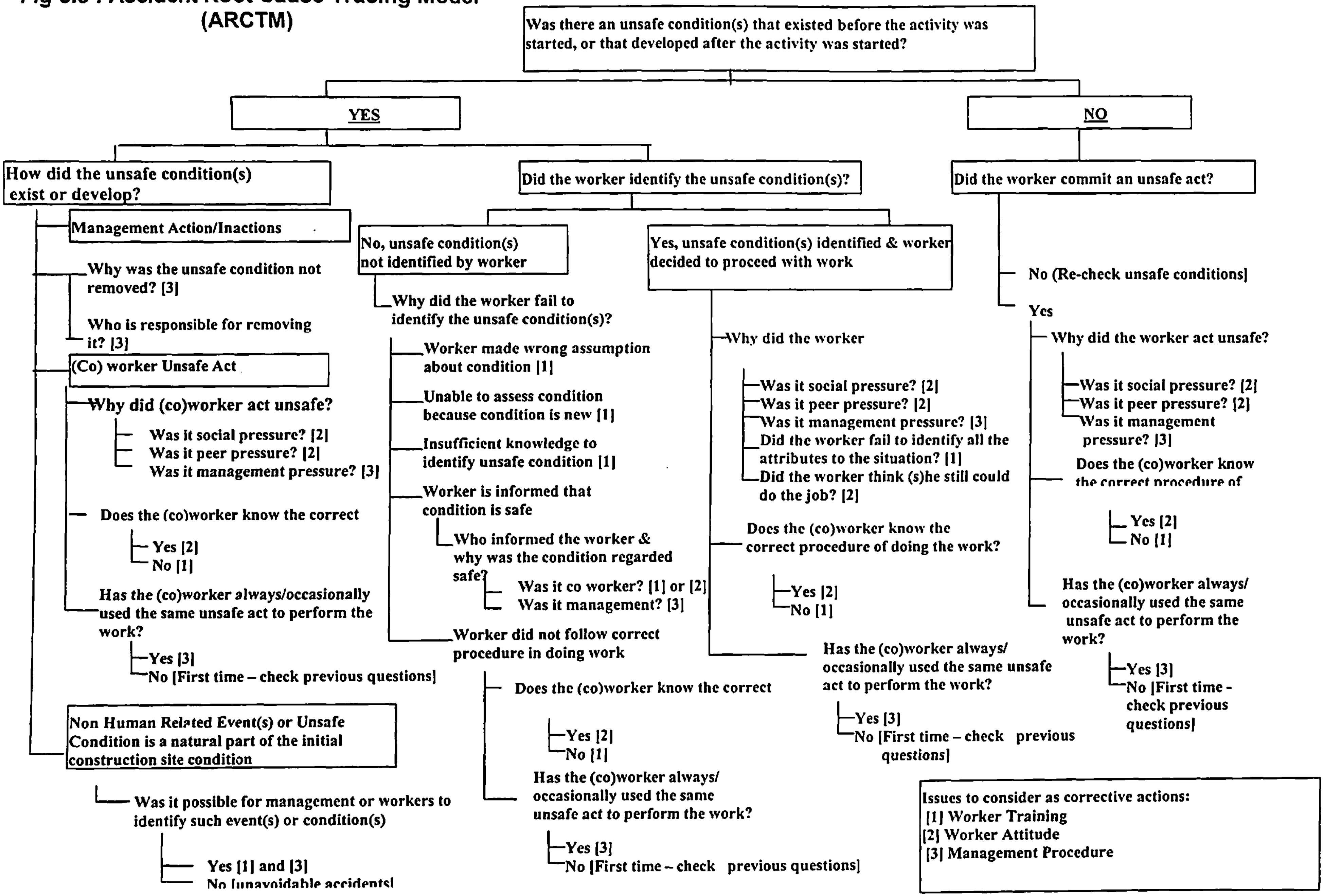
A need is felt to identify the critical issues (factors) for controlling the poor safety performance which is an essential step forward for achieving safety excellence.

3.3.2 The Accident Root Cause Tracing Model (ARCTM):

This Model was proposed by Abdelhamid & Everett (2000). The ARCTM model provides a step-by-step approach to identify the root cause(s) of construction accident. Once the root causes are identified the necessary corrective and preventive action can be planned accordingly.

The structure of the Model is depicted in Fig-3.5

Fig-3.3 : Accident Root Cause Tracing Model (ARCTM)



Source: Abdelhamid, T.S. and Everett, J.G.(2000)

The model is based on the premise that an accident occurs due to the following three root causes:

(i) Failure to identify an unsafe condition existing prior to start of work or crapped up during the execution of the work;

(ii) Decide to proceed with the work in spite of having detected an unsafe condition;

(iii) Deciding to Act unsafe ignoring the initial conditions of work environment.

As a remedy to prevent an accident through elimination of unsafe condition the model recommends:

(i) Provide training for these workers who are lacking in the same.

(ii) For the workers of having the training and awareness, attitudinal change through behavioural training is solicited for and

(iii) Identify and remove unsafe conditions in a proactive manner through management procedures and arrange for positive promotion of safety culture throughout the organization.

The model gives an insight into the various causal aspects of occurrence of accidents. However, the essence of performance measurement through the ARCTM model is not indicated. For achieving excellence in safety the performance monitoring and measurement plays a key role in attain the goal of safety (pre-defined performance outcomes). The relationship and performance improvement is also not established.

3.3.3 Leadership and Safety:

Peterson (2004) emphasizes the need for leadership in achieving safety excellence. To understand the relationship it is essential to have a clear perception of Leadership. Peterson (2004) suggests that there exists ambiguity in the perception because there are as many definitions as the number of scholars who attempted to define it. He further quoted some important definitions as:

- "Behaviour of an individual when he is directing the activities of a group towards a shared goal" (Hemphill and Connes, 1957).
- "Interpersonal influence, exercised in a situation and directed, through the communication process, towards the attainment of a specified goal or goals" Tannenbaum, et. al. 1961).

The present model on leadership believes that more than a safety programme involving a number of elements, which may vary from one Researcher to the other, it is the safety culture that plays the most important role in achieving safety excellence. A six point criteria is recommended in the model which includes (Peterson 2004):

(i) A system to enforce proactive supervision.

(ii) System to ensure that middle management tasks take care of subordinates' safety performance regularity and of predetermined quality and also ensure top managements appreciation for the importance of safety.

(iii) Safety must be visible in the organization through top managements involvement.

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(i) A system to enforce proactive supervision.

(ii) System to ensure that middle management tasks take care of subordinates' safety performance regularity and of predetermined quality and also ensure top managements appreciation for the importance of safety.

(iii) Safety must be visible in the organization through top managements involvement.

(iv) Workers should be actively engaged in meaningful safety activities.

(v) Flexibility of the safety system allowing choice of activities at all levels to obtain ownership.

(vi) Workers appreciation of the safety efforts.

The model also highlights the significance of leadership in achieving safety excellence.

The effectiveness of leadership is demonstrated through its actions and decisions. It is considered much more important than the organization's 'SHE' Policy (Peterson, 2004).

A three-step process is essential for the leadership to steer the wheels of safety excellence, these include:

(i) Determining the current status,

(ii) Decide where we want to be and

(iii) Device the process through which to go there.

In conclusion the model identifies the significant variables of organizational effectiveness w.r.t. Safety as:

(i) Amount of trust and confidence existing in the minds of the workers.

(ii) Availability of necessary resources.

(iii) Managers concern (interest) with the subordinates.

(iv) Sharing of information.

(v) Understanding of the workers problems.

(vi) Ease of access to top management.

(vii) Providing of training & helping others in accomplishment of the task.

(viii) Recognize achievements.

(ix) Coaching as to how to solve problems.

The leadership and cultural issues emphasized as critical for achievement of safety excellence is well noted. However, these are simply means to an end and not the end itself. For attaining safety excellence we need to perform better and better with regard to safety performance criteria on a continual basis. Measurement of performance is not addressed in the model. Whereas measurement is the first step in the process organizations are required to benchmark their performances with regard to safety achievements. This is more important in view of the W.T.O. & GATS issues cropped up in the recent Globalization-era.

The review of all the three models described above suggest the need for establishment of a model which identifies the critical issues which affect safety performance and a measurement of the performance for installing a process of continuous improvement towards achieving excellence.

CHAPTER – 4

METHODOLOGY

4.0 Introduction

The methodology adopted for this study consists of following activities:

I. Literature Review

II. Design & Development of Questionnaire

III. Survey Administration

IV. Analysis of Data

V. Findings

VI. Conclusion

4.1 Literature Review

Extensive review of available literature has been done to assess the current scenario of safety performance in the construction sector. The literature review has helped in identifying the various issues associated with poor safety performance of construction industry.

The issues associated with study of safety performance generally considered are: (i)Technological Issues, (ii) Organizational Issues & (iii) Behavioural Issues (Vaid 2000, Bhanushali, 2005). In the present study two more issues have been considered for better understanding of the problem. The issues included consists of:

(I) Technological Issues

(II) Organizational Issues

(III) Behavioural Issues

(IV) Performance Monitoring and Measurement Issues, and

(V) Implementation Issues.

The various issues identified through the literature review have been highlighted in chapter-2, however, the following gives an idea about the variety of issues involved.

(i) Carrying out specialized activities under proper supervision.

(ii) Hazards associated with construction machineries.

(iii) Use of defective tools and equipments

(iv) Inadequate earthing of electrical equipments

(v) Lifting equipments without proper certification.

(vi) Use of imported machinery vs. local machineries for better safety.

The above issues are considered as technological issues.

Amongst the various organizational issues some of the important issues include:

(i) Workers perception and attitude towards the job.

(ii) Project Organizational & Management set up.

(iii) Safety Management Styles.

(iv) Lack of awareness of Supervisors/ Managers regarding safety legislation.

(v) Problems of wages (Piece Rate System) of workers.

(vi) Availability of Project safety Plans.

(vii) Deployment of Qualified Safety personnel at sites.

(viii) A systematic approach with defined rcles and responsibilities, etc

Similarly the behavioural issues identification include:

(i) Supportive culture.

(ii) Top Management's commitment.

(iii) Unsafe Acts.

(iv) Safety management styles.

(v) Communication.

(vi) Lack of awareness of workers.

(vii) Proceeding with the job totally ignoring identified hazards, etc.

Performance monitoring and measurement issues comprises:

(i) Cost over-run.

(ii) Daily inspection of tools & tackles.

(iii) Rework due to unacceptable quality

(iv) Safety standards and goals (criteria of performance measurement).

(v) High accident rate.

(i) Continual monitoring of safety performance, etc.

The Implementation Issues evolved includes:

(i) Quality of Scheduling.

(ii) Insisting for total compliance to Safety Regulations.

(iii) Insufficient Incident Investigation.

(iv) Personal Involvement.

(v) Delayed completion.

(vi) Approval of Health, Safety and Environmental Plan of Contractors, etc.

Apart from identification of the issues, the literature review has also revealed the criteria for measurement of safety performance, which serves as the baseline for journey to excellence through the vehicle of continual performance improvement.

The review has further identified the lagging indicators of safety, i.e. accident frequency and severity rates as the most commonly used performance criteria. These lagging indicators have been criticized by researchers as "end of the job" observation and does not contribute to the process of continual improvement. Many researchers advocate the use of Behaviour Based Safety (BBS) approach, being a leading indicator of Safety Performance Monitoring tool. The use of BBS approach provides for the identification of 'at-risk behaviour' of workers and the path forward for their remedy. All said and done the Injury rates are considered as significant criteria for performance measurement (Mohamed, 2002) and are being followed by developed nations like U.K., US, Canada, etc. These criteria are also considered as the necessary measurement of safety performance for benchmarking purposes.

The literature review finally has indicated that there is no definite framework of safety performance improvement, which is universally applicable. This may be considered as a major gap between the existing and desired levels of safety performance and invigorates the need for a research in this area. One of the major contributions of literature review to the current research is that it has helped in preparing survey questionnaire befitting to Indian construction sector for collection of data and their analysis.

4.2 Designs and Development of Questionnaire

The present study is based on data collection through questionnaire survey. The development of questionnaire is done with literature review followed by discussions with three distinguished academicians and four practicing safety and construction professionals for correctness and specificity. Based on the inputs received coupled with researchers experience in reputed MNCs the initial questionnaire is designed.

This pilot questionnaire was issued to a few selected Project/ Safety /Construction Managers of various companies to ensure appropriateness of the same for the present study. Based on the response of the pilot study and further discussions with a few selected Professionals and Academicians the final questionnaire was developed as shown in Annexure –1.

4.3 Survey Administration

Judgmental sampling was used for the selection of potential respondents. The finalized questionnaire was issued through personal contacts and e-mail to 150 target respondents. The Respondent group targeted includes:

(i) Members of Construction Industry Development Council (CIDC).

(ii) Members of Builders Association of India (BAI)

(iii) A few selected academicians and Consultants, and

(iv) Other Construction companies through personal contact and follow up.

The activity spread of the respondents include:

(i) Buildings,

(ii) Structural Erection

(iii) Infrastructure development

(iv) Refinery/Petrochemicals

(v) Oil and Gas

(vi) Multifarious activities (Various combinations of above activity spread).

The construction activities involved Civil, Electrical, Mechanical and Instrumentation installations.

The initial response rate was only 7% spanning over a period of six months. Through vigorous persuasion and follow up the response rate improved to 30.7% during a period of 18 months of data collection. A total of 46 responses were received. The present response rate (30.7%) is adequate based on studies available in international Journals. For example, Yeats & Lockley (2002) recommended that a response rate of 27% is considered adequate for surveys. Similarly from other publications in the International literature the present response rate is considered adequate.

The response to the questionnaire was asked for in a five point (1 to 5) Likert's scale with the following notations:

1 =Totally Disagree.

2 = Tend to Agree.

3 = Neutral (Agree/disagree).

4 = Mostly Agree

5 = Totally Agree.

In support of use of Likert's scale response Keyserling, et al.(1992) suggests that "A three point check list type analysis is usually in close agreement or over estimates the risk factor when compare to the expert findings".

The demography of the respondent activity spread and volume of business (in Indian Rupees) are shown in Tables – 4.1 & 4.2 respectively.

Table 4.1 : Break up of Respondents Business Activity (Frequency Distribution)

Sl. No.	Construction Activity Details	No. Of Responses	Percentage (%)
01	Building	4	8.7 %
02	Infrastructure	12	26.1 %
03	Structural Erection	8	17.4 %
04	Refinery / Petrochemical / Oil & Gas	1	2.2 %
05	Multifarious (Combination of Building, Infrastructure, Structure Erection, Refinery etc.)	18	39.1 %
06	Others	3	6.5 %
	TOTAL	**46**	**100 %**

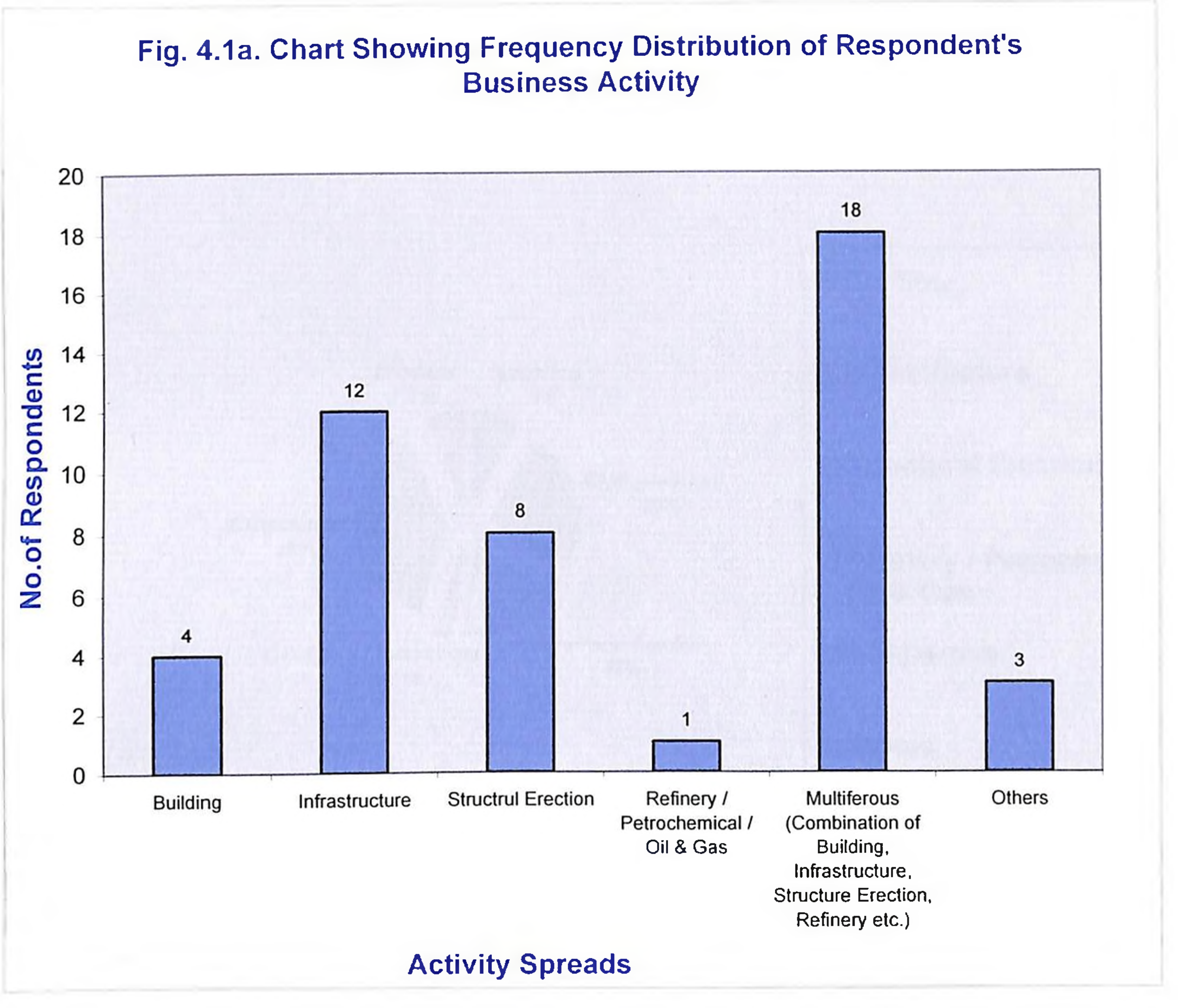


Fig. 4.1a. Chart Showing Frequency Distribution of Respondent's Business Activity
No.of Respondents
0
2
4
6
8
10
12
14
16
18
20
4
12
8
1
18
3
Building
Infrastructure
Structrul Erection
Refinery / Petrochemical / Oil & Gas
Multiferous (Combination of Building, Infrastructure, Structure Erection, Refinery etc.)
Others
Activity Spreads

Fig. 4.1b: Pie- Chart showing Percentage Break up of Respondents

Business activity

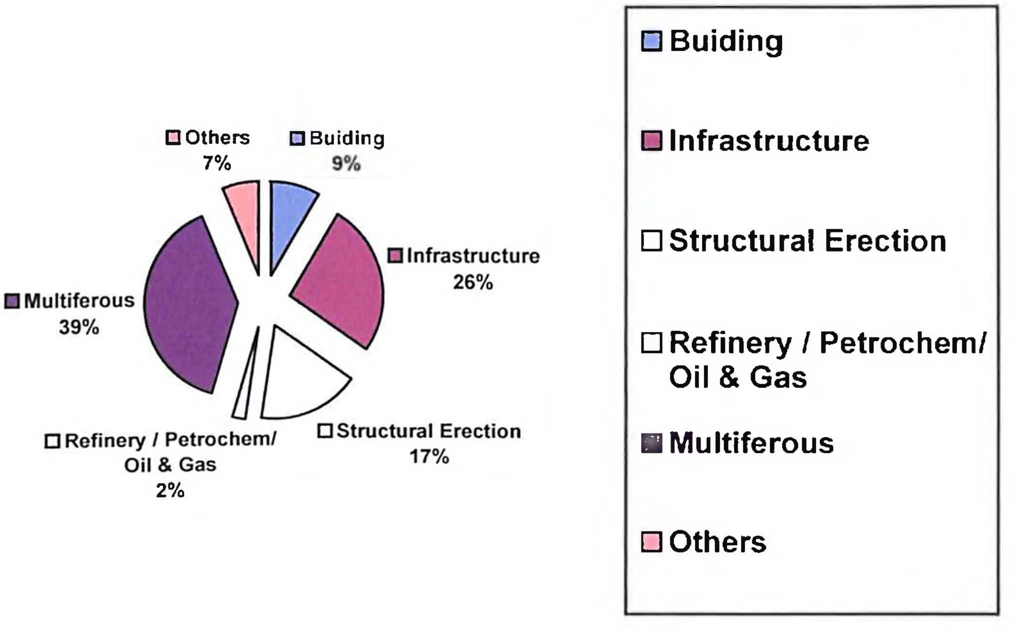


Table 4.2: Frequency Distribution of Respondents volume of business (INR)

y. No.	Volume of Business in Indian Rupees.	No. Of Respondent.
01	Upto & including Rs. 10 Crore / Annum.	6
02	Above Rs. 10 Crore upto & including 100 Crore / Annum	5
03	Above Rs. 100 Crore upto & including 500 Crore / Annum	17
04	Above Rs. 500 Crore / Annum	7
05	Value not indicated	11
	TOTAL	**46**

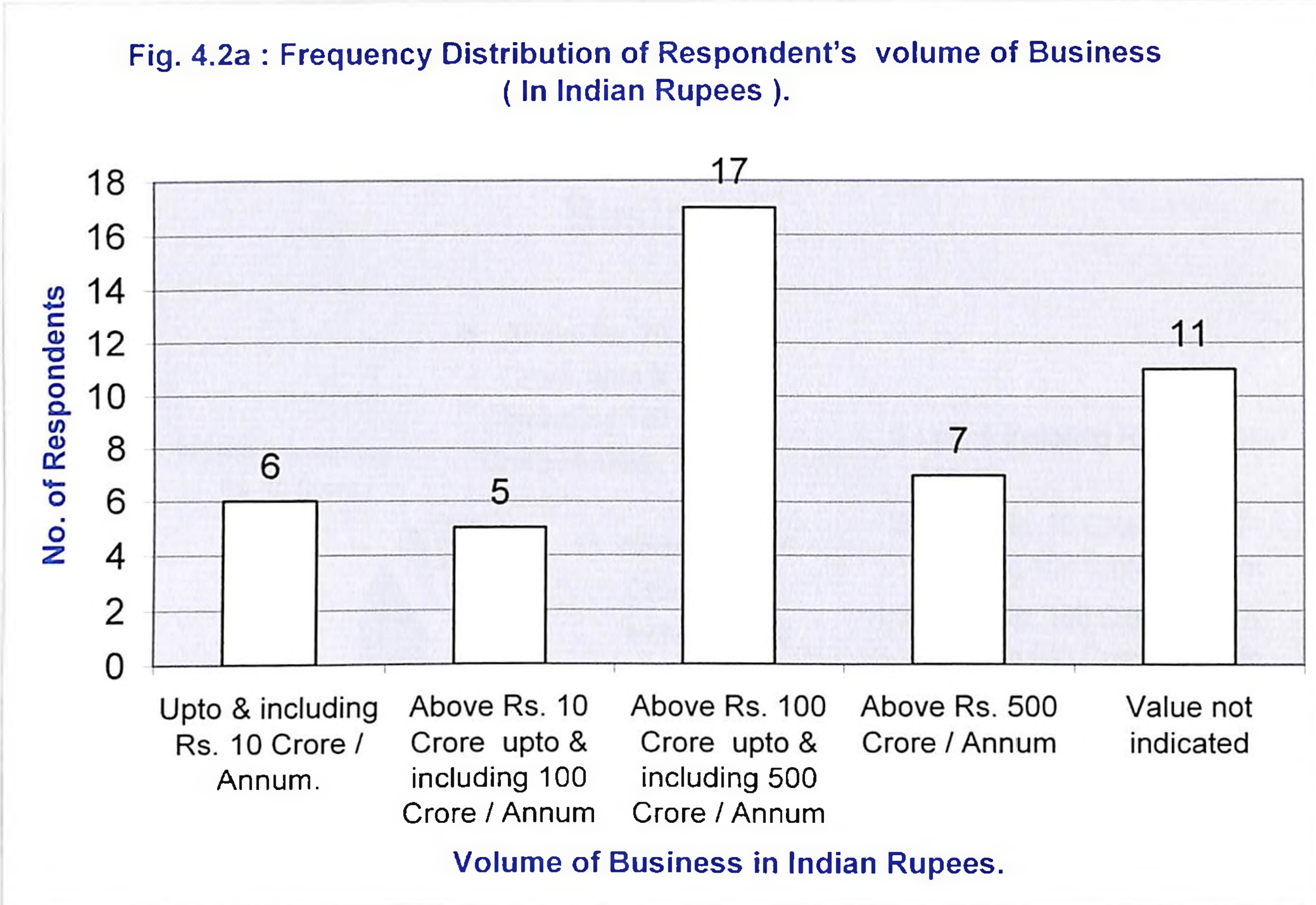
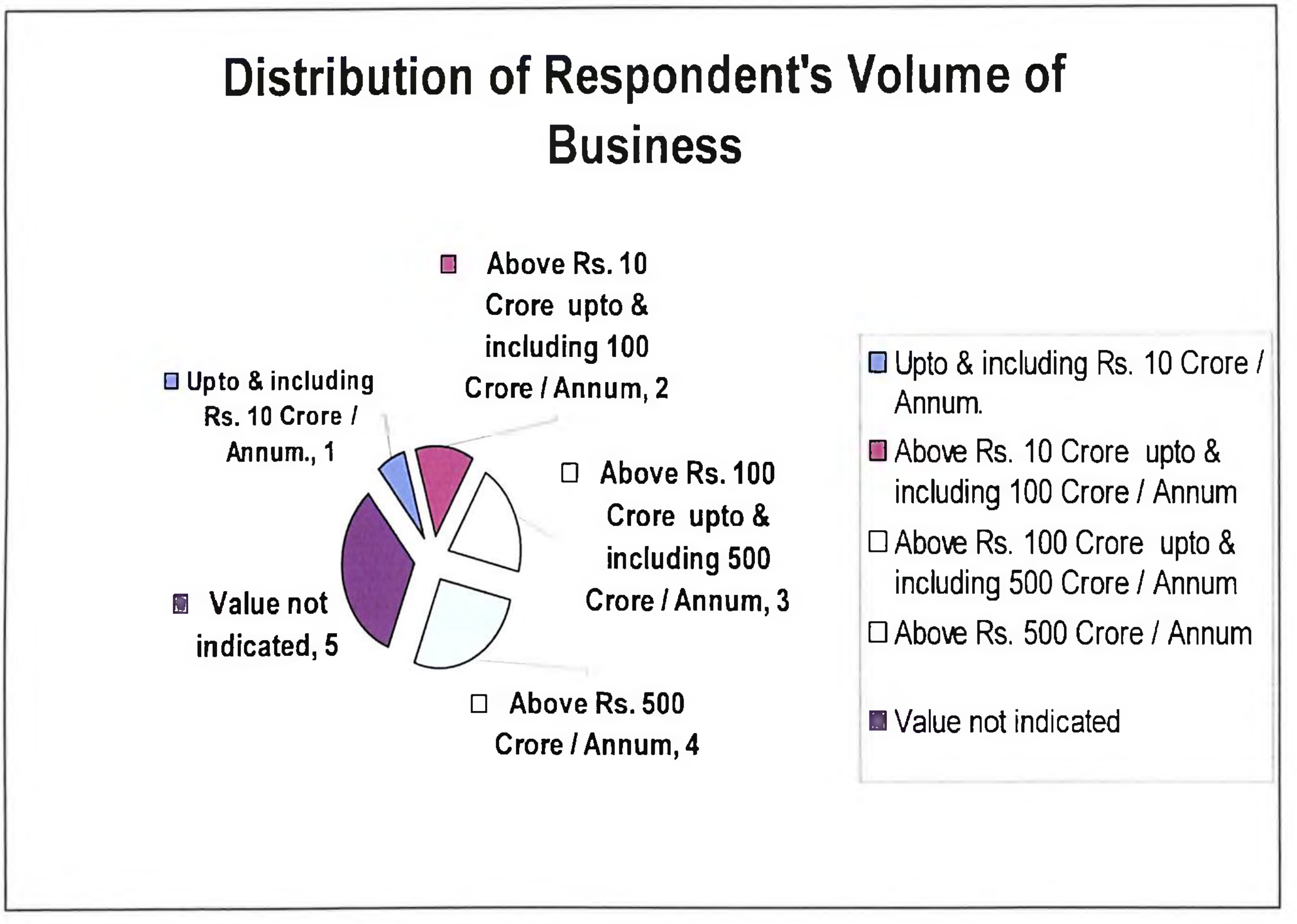


Fig. 4.2a : Frequency Distribution of Respondent's volume of Business (In Indian Rupees).
No. of Respondents
18
16
14
12
10
8
6
4
2
0
6
5
17
7
11
Upto & including Rs. 10 Crore / Annum.
Above Rs. 10 Crore upto & including 100 Crore / Annum
Above Rs. 100 Crore upto & including 500 Crore / Annum
Above Rs. 500 Crore / Annum
Value not indicated
Volume of Business in Indian Rupees.

Fig. 4.2 b : Distribution of Respondent's Volume of Business



4.4 Analysis of Data

The responses to the questionnaire are checked for their completeness and adequacy for the study. It is observed that of the 46 total responses received only 15 contained safety performance statistics for a period of five years or part thereof. To overcome the difficulties a mode analysis of all the questionnaire was done for the three groups, viz., (i) 15 response containing safety performance input, (ii) balance 31 responses where safety performance input is missing, and (iii) total 46 response. The results of mode analysis are shown in Table 4.3.

Table 4.3: Mode Analysis of Questionnaire Response

Sl. No.	Question Ref. No.	Mode of Response			Remarks
		46 Response (Total)	15 Response (with Safety Data)	31 Response w/o Safety Data	
1	1	3	4	3	Tech. issues
2	2	4	3	4	Tech. issues
3	3	5	4	5	Tech. issues
4	4	5	4	5	Tech. issues
5	5	3	3	4	Tech. issues
6	6	3	3	3	Tech. issues
7	7	4	4	4	Tech. issues
8	8	5	5	5	Tech. issues
9	9	3	3	3	Tech. issues
10	10 (i)	4	4	4	Tech. issues
11	10 (ii)	4	4	4	Tech. issues
12	10 (ii)	5	4	5	Tech. issues
13	10 (iv)	5	4	5	Tech. issues
14	10 (v)	5	5	5	Tech. issues
15	10 (vi)	4	3	4	Tech. issues
16	11	5	5	5	ORG. Issues
17	12	5	5	5	ORG. Issues
18	13	1	1	1	ORG. Issues

Mode Analysis of Response Contd...

Sl. No.	Question Ref. No.	Mode of Response			Remarks
		46 Response (Total)	15 Response (with Safety Data)	31 Response w/o Safety Data	
19	14	1	1	1	ORG. Issues
20	15	5	5	5	ORG. Issues
21	16	5	5	5	ORG. Issues
22	18	5	5	5	ORG. Issues
23	20	5	5	5	ORG. Issues
24	22	5	5	5	ORG. Issues
25	23 (i)	5	5	5	ORG. Issues
26	23 (ii)	5	5	5	ORG. Issues
27	23 (iii)	5	4	5	ORG. Issues
28	23 (iv)	3	3	3	ORG. Issues
29	23 (v)	4	4	4	ORG. Issues
30	23 (vi)	4	4	4	ORG. Issues
31	23 (vii)	4	4	4	ORG. Issues
32	23 (viii)	5	4	5	ORG. Issues
33	24	5	5	5	Behavioral Issues
34	25	5	5	5	Behavioral Issues
35	26	5	5	5	Behavioral Issues
36	27	3	3	5	Behavioral Issues
37	28 (i)	4	4	4	Behavioral Issues
38	28 (ii)	3	3	3	Behavioral Issues
39	28 (iii)	5	5	4	Behavioral Issues
40	29 (i)	4	4	3	Behavioral Issues
41	29 (ii)	4	4	4	Behavioral Issues
42	29 (iii)	5	5	3	Behavioral Issues
43	30 (i)	5	5	4	Perf. Mon.& Meas Issues
44	30 (ii)	5	5	5	Perf. Mon.& Meas Issues
45	30 (iii)	5	5	4	Perf. Mon.& Meas Issues
46	31 (i)	5	4	5	Perf. Mon.& Meas Issues

Mode Analysis of Response Contd...

Sl. No.	Question Ref. No.	Mode of Response			Remarks
		46 Response (Total)	15 Response (with Safety Data)	31 Response w/o Safety Data	
47	31 (ii)	5	5	4	Perf. Mon.& Meas Issues
48	31 (iii)	5	5	5	Perf. Mon.& Meas Issues
49	31 (iv)	5	5	4	Perf. Mon.& Meas Issues
50	32 (i)	5	4	5	Perf. Mon.& Meas Issues
51	32 (ii)	2	3	2	Perf. Mon.& Meas Issues
52	32 (iii)	4	4	4	Perf. Mon.& Meas Issues
53	32 (iv)	5	5	5	Perf. Mon.& Meas Issues
54	32 (v)	5	4	5	Perf. Mon.& Meas Issues
55	33	5	5	5	Perf. Mon.& Meas. Issues
56	34	5	4	5	Perf. Mon.& Meas. Issues
57	35 (i)	5	5	5	Implementation Issues
58	35 (ii)	5	5	4	Implementation Issues
59	35 (iii)	5	5	5	Implementation Issues
60	35 (iv)	5	5	5	Implementation Issues
61	35 (v)	4	5	4	Implementation Issues
62	35 (vi)	4	5	4	Implementation Issues
63	35 (vii)	5	4	5	Implementation Issues
64	35 (viii)	5	5	4	Implementation Issues
65	35 (ix)	5	5	5	Implementation Issues

Mode Analysis of Response Contd...

Sl. No.	Question Ref. No.	Mode of Response			Remarks
		46 Response (Total)	15 Response (with Safety Data)	31 Response w/o Safety Data	
66	35 (x)	5	5	5	Implementation Issues
67	35 (xi)	5	5	5	Implementation Issues
68	35 (xii)	5	5	5	Implementation Issues
69	35 (xiii)	4	4	4	Implementation Issues
70	35 (xiv)	5	5	5	Implementation Issues
71	36 (i)	4	5	4	Implementation Issues
72	36 (ii)	5	5	5	Implementation Issues
73	36 (iii)	4	4	4	Implementation Issues
74	36 (iv)	4	4	4	Implementation Issues

The Mode analysis of response indicates the fact that there is a good amount of agreement between the responses from the group of 15, which has furnished input for safety performance to the other group of balance 31 responses where safety input is not furnished.

This is evident from Table - 4.4

Table 4.4: Extent of Conformance of Mode of Responses

Sl.No	Category of Questionnaire	Conformance to Response '5' Totally Agree	Conformance to Cumulative Response '5' &'4' (Totally agree & Mostly agree)	Varying response mode (Neutral vs. others)	Remarks
1.	Technological	7/15 (46.7%)	11/15(73.3%)	4/15(26.7%)	Mostly Conforming
2.	Organizational	15/17(88.2%)	17/17(100%)	NIL	Fully conforming
3.	Behavioural	6/10 (60%)	8/10(80%)	2/10(20%)	Mostly Conforming
4.	Performance Mon. & Measurement	5/14(35.7%)	13/14(92.9%)	1/14 (7.1%)	Mostly Conforming
5.	Implementation	12/18 (66.7%)	18/18(100%)	NIL	Fully conforming

From the response mode analysis results it may be reasonable to assume that the 15 responses with safety performance data represents the entire population of responses. The present study is therefore, based on the analysis of these 15 responses. Further more these responses were replicated over a period of five years since the safety performance data were asked for five years. This was necessary for obtaining the response population for analyzing the data statistically so that a reliable conclusion can be arrived at. The analysis excludes responses on financial data related to Question nos. 17(i), 17(ii), 19 and 21 due to the fact that generally respondents are not open to such questions and the authenticity of the data could not be established. Question no.30 (iv) is also excluded from the analysis due to the fact that most of the respondents did not answer this question being not in practice excepting only one respondent.

4.4.1 The Type of Analysis of Data

The survey response was collated and analysed for the following:

i) Mode analysis to understand the significance of the various issues in relation to safety performance based on perception of the respondents.

ii) Correlation analysis to identify the various issues bearing significant correlation with the safety performance criteria, and

iii) Regression analysis to determine the model – fit between the independent variables (various issues represented by the survey questionnaire) and the dependent variable (Safety performance outcome) and to recommend a model of safety performance measurement criteria.

The safety performance outcomes considered in the present study are

i) Frequency rate of Lost Time Accident (FRLTA)

ii) Frequency rate of Recordable Incidence (FRRI) and

iii) Severity rate of Lost Time Accident (SRLTA)

The analysis of data was done using **SPSS – 11.0**

4.4.2 Extent of Analysis

The Survey response are analyzed separately for the five types of Issues, viz., Technological, Organizational, Behavioural, Performance Monitoring & Measurement and Implementation. This analysis identifies the significant issues amongst the various issues in the above categories.

In the real life scenario we do not expect safety to be affected by any one of the above five issues individually. The next step of analysis therefore, involves analysis of all the five types of issues together. This is done in order to identify the significant issues affecting safety performance when all of the issues are taken together. Finally the analysis is aimed at suggesting a recommended Model of safety Performance.

4.5 Findings

The analysis and findings of technological, organizational and behavioural issues are brought out in Chapter 5. Analysis of Performance monitoring and measurement issues and Implementation issues are shown in Chapter 6. The combined effects of all the issues are included in Chapter 7.

4.6 Conclusion

The Conclusion of the results of analysis and outcome of the study is brought out in Chapter-8. Conclusion also points out to the recommendations of the research and limitations/ further scope of study.

CHAPTER – 5

ANALYSIS OF TECHNOLOGICAL, ORGANIZATIONAL & BEHAVIOURAL ISSUES

5.0 Introduction

The analysis of data related to Technological, Organizational and Behavioral issues are done to establish the significance of the issues in relation to construction safety performance. The analysis also attempts to evolve an empirical model for continual improvement of safety performance in construction.

5.1 Technological Issues

For the purpose of identifying significant technological aspects of safety management practices in the Indian Construction Sector, a set of questionnaire (ref. Annexure-1A) was developed and sent to selected Construction Organizations, Engineers & Consultants.

Three stage analysis of data are conducted to determine:

(i) The modal response of the construction industry about their perception of the various factors under technological issues.

(ii) The correlation of safety performance indices with respect to various factors and

(iii) Regression of the factors (independent variables) with the outcome (dependent variable) safety measures.

The analysis is done using **SPSS 11.0** software. (http: // www.phych.utoronto.ca / courses / c1 / spss / page1.htm)

5.1.1 Results of 'MODE' analysis

From the mode analysis the Technological Issues are categorized into 3 groups viz., 1, 2 & 3 depending upon the respondents' perception of their significance for achieving better safety performance as elaborated in Table- 5.1:

Table- 5.1 : Classification of Technological Issues based on Mode Analysis.

Sl.No.	Type of Issues	Group 1 (Q.Nos.)	Group 2 (Q.Nos.)	Group 3 (Q.Nos.)	Remarks, if any
1	Technological Issues (TI).	8, 10 (iii), (iv) & (v) (Total 4)	10 (i), (ii) & (vi), 2, 3, 4 & 7 (Total 7)	1, 5, 6 & 9 (Total 4)	Out of 15 Nos. of Issues 11 issues are identified as totally agree and Mostly agree. The remaining 4 are neutral.

Legend: Group 1: Issues having Likert's Responses '5' (Totally Agree)

Group 2: " " " " '4' (Mostly Agree)

Group 3: " " " " '3' (Neutral)

Response 2 & 1 being tend to agree and totally disagree are considered less important for the present analysis.

The details of classifications of various issues in Table - 5.1 are explained in Table - 5.2.

Table-5.2: Description of Technological Issues classified in Groups 1, 2 & 3.

Sl. No.	Survey Question No.	Description
	Group-1 : Totally Agree	
01	(8)	Specialized activities involved in excavation, trenching, tunneling, erection of structures, if carried out by unskilled workers without proper supervision by trained and qualified persons, pose a serious threat to safety.
02	(10)	The following are considered significant in the prevention of accidents/ injuries :
	(iii)	Damaged insulation of cables
	(iv)	Inadequate earthing of electrical equipment
	(v)	Mechanical handling equipments with proper certification.
	Group-2 : Mostly Agree	
03	(10)	The following are considered significant in the prevention of accidents/ injuries:
	(i)	Defective hand tools & power tools.
	(ii)	Routine inspection of lifting tools & tackles.
	(vi)	Poor House Keeping.
04	(2)	Imported machineries/ equipments provide better safety in their use than compared to domestic equipments.
05	(3)	While importing such machinery one should always insist for training of employees to ensure better safety & productivity.
06	4	Ensure availability of Material Safety Data Sheets (MSDS) for use of various chemicals to prevent any inadvertent misuse/ improper handling and storage leading to safety hazards.
07	7	Excepting a very few manufacturers, generally no other Manufacturer provides training to buyers personnel in the safe handling and routine periodic maintenance of the plants and equipments supplied.

Sl. No.	Survey Question No.	Description
GROUP-3: NEUTRAL		
08	1	Uses of construction Machineries/ Equipments (Mixing/ Batching Plants, Concrete Pumps, Shovels, Dumpers, Excavators, Welding Equipments, DG Sets, etc.) possess safety hazards in execution of work.
09	5	Indigenously developed plants and equipments, in general are not designed to include the operator's health & safety and ease of handling aspects.
10	6	Manufacturers of indigenously developed plants and equipment do not provide Safety Manual to their Buyers.
11	9	Most of the accidents/ injuries occur at project sites are due to defective tools and equipments

5.1.2 Correlation Analysis

Technological Issues are analyzed for their correlation (Pearsons 2-tailed, bi-variate) with the following three kinds of safety performance measures:

i) Frequency Rate of Lost Time Accident (FR LTA) Q.No. 11(i) Annexure-1A

ii) Frequency Rate of Recordable Incidences (FRRI) Q. No. 11(ii) Annexure-1A

iii) Severity Rate of LTA (SR LTA) Q no 11(iii) Annexure-1A.

The results showing various technological factors/(Issues) having significant correlation (Pearson 2-tailed, bi-variate) with the above three performance measures at 0.01 level (**) and 0.05 level (*) are highlighted in Table-5.3.

Table 5.3: Technological issues (as per annexure-1A) having significant correlations with safety performance indicators (FRLTA, FRRI & SRLTA)

Sl. No.	Correlation of factors (Q. Nos.) against FR LTA		Correlation of factors (Q.Nos.) against FRRI		Correlation of factors (Q. Nos.) against SR LTA	
	Factor	Correlation	Factor	Correlation	Factor	Correlation
1	Q. 8	- 0.325 *	Q. 1	0.400 *	Q. 5	0.280 *
2	Q10(v)	- 0.317 *	Q. 4	- 0.419 **	Q. 6	0.444 **
3	-	-	-	-	Q. 2	0.309 *
4	-	-	-	-	Q. 10 (v)	0.407 **
5	-	-	-	-	Q.10 (vi)	0.430 **

** Correlation is significant at 0.01 level (2- tailed)

* Correlation is significant at 0.05 level (2- tailed)

5.1.3 Regression Analysis

The analysis is done with Q. Nos. 1 up to 10 (vi) as independent variables identified in the SPSS output as VAR00001 to VAR00015 and Q no. 11 (Safety Performance Data) as the dependent variable identified as VAR000016.

The regression output of technological issues are studied with regard to the three performance criteria namely FRLTA, FRRI & SRLTA discussed above and results are as described below:

5.1.3.1 Regression with Frequency Rate of LTA (FRLTA)

The model summary of regression obtained from SPSS output is shown in Table- 1 of Annexure - 3.

From the Table it is apparent that the regression fit (R^2 = 0.406) of Technological issues with LTA frequency rate is not enough to suggest a strong empirical Model.

5.1.3.2 Regression with Frequency Rate of Recordable Incidence (FRRI)

The SPSS output for Regression of FRRI with the various Technological issues were analyzed from the Model summary as per Table- 2 of Annexure - 3

As can be seen from the model summary, R^2 value is 0.750 meaning thereby a moderate regression fit exists between the Technological issues represented by the predictors in the model and the safety performance criterion i.e., Frequency Rate of Recordable Incidence (FRRI). These predictor variables can be identified from Q. Nos. in annexure –1A with the notation that VAR nos. 00001, 00002 etc represent Q. Nos. 1,2 etc. as described in the Annexure -1A. The predictor variables include hazards from machinery, use of imported machinery, training for use of imported machinery, availability of MSDS for chemicals, supply of safety manual with indigenous plants/ equipments, carrying out specialized jobs under proper supervision of trained and qualified personnel

An empirical suggestive model is derived from the coefficients in the SPSS output for Regression shown in Table – 5.4

Table - 5.4 : Coefficients[a] of Technological issues in regression analysis with FRRI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-39.494	12.497		-3.160	.004
	VAR00001	2.111	.500	.762	4.220	.000
	VAR00002	7.951	1.516	1.083	5.243	.000
	VAR00003	2.309	.656	.646	3.522	.001
	VAR00004	.143	.988	.025	.145	.886
	VAR00006	1.043	.359	.326	2.903	.007
	VAR00008	-3.139	.582	-601	-5.390	.000
	VAR00010	-3.666	.537	-1.375	-6.822	.000
	VAR00013	3.778	.643	1.143	5.873	.000
	VAR00014	2.963	.827	.677	3.585	.001

a. Dependent Variable: VAR00016

Suggested Model for Frequency Rate of Recordable incidence (**FRRI**) derived from the above coefficients can be expressed as:

$$\mathbf{FRRI = -39.494 + 2.111V1 + 7.951\,V2 + 2.309\,V3 + 1.043\,V6 - 3.139\,V8 - 3.666\,V10 + 3.778\,V13 + 2.963\,V14} \quad \ldots\ \ldots\ \ldots\ \ldots \quad \textbf{(Eq. 5.1)}$$

Where V1, V2, V3 .... etc. are the predictor variables listed under the coefficients in Table-5.4 , viz., VAR0001, VAR0002...respectively and represent the Q. Nos. 1, 2, 3,4,6,8,10,(i), 10(iv) and 10(v). From the Table of coefficients the 't' statistics for V4 (=0.145) and corresponding 'significance' score (0.886) indicate that the relative importance of V4 in the model is very low as compared to other predictor variables. Hence V4 is not included in the model.

5.1.3.3 Regression with Severity Rate of LTA (SRLTA)

The response data on Severity Rate of Lost Time Accident (SRLTA) was processed with SPSS 11 software to determine the model summary and identify outlier, if any, through Case Wise Diagnostic. The Model summary is shown in Table – 3 of Annexure - 3.

From the model summary it may be inferred that the regression fit (R^2=0.894) of predictor variables versus the output variable (SRLTA) is quite strong. Further case wise diagnostics (appended in Table – 4 of Annexure – 3) was used to identify the outlier and run the SPSS programme for obtaining an improved model.

Case wise Diagnostics identified Case number 1 as an Outlier, which was removed from the initial data set, and SPSS was run again. The revised model Summary obtained is shown in Table – 5 of Annexure - 3

The model summary above shows a great improvement in the regression fit indicated by R-square value (0.941) with the exclusion of outlier. Following from this analysis, the coefficients of predictors are determined for development of a suggested model for SRLTA.

The Coefficients of the Predictors in the model are as per Table - 5.5

Table - 5.5 : **Coefficients[a] of Technological issues in Regression Analysis with SRLTA**

		Un standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	-3261.385	1346.360		-2.422	.020
	VAR00001	351.458	77.518	.464	4.534	.000
	VAR00002	55.233	124.899	.055	.442	.661
	VAR00003	680.472	68.169	.840	9.982	.000
	VAR00004	-422.668	153.429	-.396	-2.755	.009
	VAR00006	252.143	51.224	.366	4.922	.000
	VAR00008	924.930	170.578	.832	5.422	.000
	VAR00010	782.208	166.396	1.059	4.701	.000
	VAR00011	-1153.897	138.367	-1.160	-8.339	.000
	VAR00012	-946.769	146.084	-1.169	-6.481	.000
	VAR00014	-90.673	103.917	-.098	-.873	.388
	VAR00015	531.118	120.224	.701	4.418	.000

a Dependent Variable: VAR00016

From the data on 'coefficients' the suggested empirical model for Severity Rate of LTA is obtained as noted below:

$$\mathbf{SRLTA} = -3261.385 + 351.458\, V_1 + 680.472\, V_3 - 422{,}668\, V_4 + 252.143\, V_6 + 924.930\, V_8 + 782.208\, V_{10} - 1153.897\, V_{11} - 946.769\, V_{12} + 531.118\, V_{15} \quad \text{(Eq. 5.2)}$$

Where V1, V2, V3 .... etc. are the predictor variables listed under the coefficients in Table-6 , viz., VAR0001, VAR0002 ... respectively and represent the Q. Nos. 1, 2, 3,4,6,8,10,(i), 10(iv) and 10(v).

It may be pointed out here that the 't' statistics for variables VAR00002 (Q no. 2) and VAR00014 (Q No.10v) indicate that their relative importance in the model is very low and hence these are not included in the model.

5.1.4 Findings

From the Mode analysis of survey data the following four Technological issues are found to play the most significant role for safety performance improvement as per the perceptions of the respondents.

- Carrying out Construction activities under supervision of trained and qualified persons.
- Control of hazards of damaged insulation of cables.
- Inadequate earthing of electrical equipment, and
- Use of mechanical handling equipment with proper certification.

Besides above, the following seven Technological issues are found to be significant for safety performance improvement:

- Defective hand tools & power tools.
- Routine inspection of lifting tools & tackles.
- Poor House Keeping.
- Use of Imported machineries/ equipments for better safety.
- Insisting for training of employees to ensure better safety & productivity.

- Ensure availability of Material Safety Data Sheets (MSDS) for use of various chemicals.
- Training of buyer's personnel in safe handling and routine periodic maintenance by the suppliers of plants and equipments.

The balance four Technological issues, viz., (i) hazards from construction machinery/equipment, (ii) operators safety from indigenously developed plants/ equipments, (iii) manufacturer' safety manual for indigenously developed plants & (iv) equipments and accidents from defective tools and equipments are found to have neutral response as far as safety performance is concerned.

The study further establishes significant correlations of various technological issues with the three criteria for safety performance measurement as follows:

(i) Frequency Rate of Lost Time Accident (FRLTA) is found to have negative correlation with the following Technological issues:

- Carrying out specialized activities under supervision of trained and qualified person ($p=0.05$) and
- Use of Mechanical handling equipments with proper certification ($p= 0.01$)

The negative correlation is also in agreement with practical experience with regard to accident prevention since with increased supervision by trained and qualified person, the rate of accident is generally found to decline. Same is the case with Mechanical handling equipment with proper certification

(ii) Frequency Rate of Recordable Incidences (FRRI) is observed to have correlations with the two Technological issues as noted below:

- Hazards from construction machinery/ equipments ($p=0.05$) and

- Availability of MSDS for various chemicals (p=0.01).

(iii) Severity Rate of Lost time Accident (SRLTA) is found to have correlation with the following five Technological Issues:

- Use of imported machinery (p=0.05)
- Operators safety from indigenously developed plants/equipments (p=0.01)
- Supply of safety manual with indigenous plants/ equipments (p=0.01)
- Mechanical handling equipment with proper certification (p=0.01)
- Poor housekeeping (p=0.01)

The correlation analysis results show skewness in some cases. This may be due to various reasons like lesser number of response, partial response and inaccurate information with regard to performance data. This can be overcome with more and more voluntary participation of the construction industry with proper recording of data.

The study also recommends a linear regression Model of SRLTA with the various technological issues as depicted above in Para 5.1.3.3. The R^2 value of 0.941 suggests a strong fit of the variables (technological issues) with the outcome performance (SRLTA).

Likewise regression analysis of Frequency Rate of Recordable Incidence (FRRI) with the technological issues has been studied. The R^2 value of 0.750 suggests a moderate fit of linear regression between the variables with outcome. An empirical model for Regression of FRRI with Technological issues is also recommended under Para 5.1.3.2

In both the cases the predictors to the model V1, V2 represent the survey Question Nos. 1, 2, etc. of Annexure -1A.

Regression analysis for technological issues with LTA Frequency rate shows a R^2 value of 0.406 and an effective model of regression fit between Technological issues with FRLTA could not be recommended.

The present study recommends a model for monitoring of Frequency Rate of Recordable Incidence and that of Severity Rate of Lost Time Accident. It is interesting to note that the predictor variables in the Model for FRRI are also included in the model for SRLTA.

The proposed models could be made stronger and effective tools for improvement of construction safety performance through whole hearted participation of construction organizations of all categories like, large, medium and small so that a good number of completed response are received for further analysis.

5.2 Organizational Issues

Responses to organizational issues have been analyzed for mode, correlation and regression to establish the significant issues and suggest an empirical model for performance measurement. The details of the questionnaire is attached at Annexure –1B.

5.2.1 Mode analysis

Mode analysis highlights the categorization of issues into three categories viz., Group-1 (totally agree), Group-2 (mostly agree) and group –3(neutral) as explained in Para 5.1 .1 above. The details are as shown in Table 5.6

Table 5.6 : Classification of Organizational issues as per Mode Analysis.

Sl. No.	Type of Issues	Group 1 (Q.Nos)	Group 2 (Q.Nos.)	Group 3 (Q.Nos.)	Remarks, if any
1	Organizational Issues (OI)	1,2,5,6,7,8, 9,10(i),10(ii), 10(v), 10(vii),10 (viii). (Total 12nos.)	10(iii),10(vi). (Total 2 nos.)	10(iv) (1 no.)	Out of 17 Nos. of Issues 14 have been identified as totally agree and Mostly agree. Of the remaining 3, 1(Q. no 10iv) is identified as neutral and Q Nos 3&4 are totally disagreed.

Legend: Group 1: Issues having Likert's Responses '5' (Totally Agree)
Group 2: " " " " '4' (Mostly Agree)
Group 3: " " " " '3' (Neutral)

The details of classifications of various Issues in Table-5.11 are explained in Table 5.7

Table - 5.7 : Description of Organizational Issues classified in Groups 1,2&3.

S.No.	Survey Question No.	Description
Group-1 : Totally Agree		
01	1	Establish Project Safety Policy and Objectives
02	2	Project Safety plan.
03	5	Safety Team comprising representatives of contractors and subcontractors.
04	6	Client's participation in site safety team.
05	7	Selection of Subcontractors based on their past safety record.
06	8	Monitor effectiveness of safety programme through Cost of Quality approach.
07	9	Believe in the fact that most of the accidents occur during normal working hours
08.	10(i)	A systematic approach, defined roles and responsibilities and two-way communication are essential prerequisite for safety excellence.
09.	10(ii)	Lack of proper training is an impediment for safety excellence.

S.No.	Survey Question No.	Description
10.	10(v)	Awareness of Occupational hazards helps in achieving safety excellence.
11.	10(vii).	Prioritization of schedule and cost over safety lead to job site accidents.
12.	10(viii).	Lack of knowledge on safety legislation may lead to continued exposure to unsafe condition.
Group-2: Mostly Agree		
01.	10(iii).	Deficient enforcement of safety is an impediment to safety excellence.
02.	10(vi).	Workers involvement in implementation of safety procedure and manual helps in achieving excellence.
Group-3: Neutral		
01.	10(iv).	Problems of wage and job security are a hindrance to safety excellence.

5.2.2 Correlation Analysis

Organizational factors are analyzed for their correlation (Pearsons 2-tailed bi-variate) with the following three kinds of safety performance measures:

i) Frequency rate of Lost Time Accident (FR LTA) Q.No 11(i) of annexure-1B

ii) Frequency Rate of Recordable Incidences (FRRI) Q no 11(ii) of annexure-1B

iii) Severity Rate of LTA (SR LTA) Q no 11(iii) of annexure-1B.

The results showing various organizational factors having significant correlation (Pearson 2-tailed, bi-variate) with the above three performance measures at 0.01 level (**) and 0.05 level (*) are highlighted in Table-5.8

Table 5.8 : Organizational issues (as per annex-1B) having significant correlations with safety performance indicators (FRLTA, FRRI & SRLTA)

Sl. No.	Correlation of factors (Q. Nos.) against FR LTA		Correlation of factors (Q Nos.) against FR RI		Correlation of factors (Q Nos.) against SR LTA	
	Factor	Correlation	Factor	Correlation	Factor	Correlation
1	Q.3	.427**	--	--	Q3	-.441**
2	Q.4	.605**	--	--	Q.4	-.402**
3	Q10(iii)	-.291**	-	-	Q6	.427**
4		-	-	-	Q7	.350*
5					Q9	-.383**
6					Q10(i)	.369*
7.					Q. 10(ii)	.360**
8.	-	-	-	-	Q10(iv)	-.487**

** Correlation is significant at 0.01 level (2 tailed)
* Correlation is significant at 0.05 level (2 tailed)

5.2.3 Regression Analysis

The analysis is done with Q. nos. 1 upto 10 (viii) as independent variables identified in the SPSS output as VAR00001 to VAR00017 and Q no. 11 (Safety performance data) as the dependent variable identified as VAR000018.

The regression output of organizational issues are studied with regard to the three performance criteria namely FRLTA, FRRI & SRLTA discussed above and results are as described below:

5.2.3.1 Regression with Frequency Rate of LTA (FRLTA)

The model summary of regression obtained from SPSS output is shown in Table - 1 of Annexure - 3

From Table referred to above, it is apparent that the regression fit (R^2 =0.369) of organizational issues with FRLTA is not enough to suggest a strong empirical Model.

5.2.3.2 Regression with Frequency Rate of Recordable Incidence (FRRI)

The SPSS output for Regression of FRRI with the various Organizational issues are studied from the Model summary as per Table-2 of Annexure - 3

The R^2 value of 0.262 in the model summary does not lead us to recommend a strong regression model.

The regression output also points out (in case wise diagnostic) the case numbers 11 and 12 as outliers. After removal of these cases the regression model summary remains unchanged and therefore regression model for FRRI with organizational issues could not be recommended.

5.2.3.3 Regression with Severity Rate of LTA (SR LTA)

The response data on Severity Rate of Lost Time Accident (SRLTA) are processed to determine the model summary and identify outlier(s), if any, through Case wise Diagnostic. The Model summary is shown in Table -3 of Annexure - 3

From the model summary it may be inferred that the regression fit (R^2=0.893) of predictor variables versus the output variable (SRLTA) is quite strong. Further case wise diagnostics (appended in Table – 4 of Annexure – 3) identifies case no.1 as the outlier.

The outlier (case no.1) identified above is removed from the initial data set and SPSS is run again. The revised Model summary obtained is shown in Table – 5 of Annexure - 3.

The model summary referred to above shows a great improvement in the regression fit indicated by R-square value (0.945) with the exclusion of outlier. Following from this analysis the coefficients of predictors are determined for development of a suggested model for SRLTA.

The Coefficients of the Predictors in the model are as per Table 5.9

Table - 5.9 : Coefficients[a] of Organizational issues in Regression Analysis with SRLTA

		Un standardized Coefficients		Standardized Coefficients	T	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	-4515.746	695.559		-6.492	.000
	VAR00003	-219.081	33.038	-.485	-6.631	.000
	VAR00007	109.835	51.308	.120	2.141	.040
	VAR00008	-332.309	47.051	-.546	-7.063	.000
	VAR00011	1532.059	131.338	.967	11.665	.000
	VAR00012	724.661	84.662	.589	8.559	.000
	VAR00015	457.416	71.776	.462	6.373	.000
	VAR00016	-1312.484	79.239	-1.464	-16.564	.000
	VAR00017	48.137	56.156	.042	.857	.398

a Dependent Variable: VAR00018

From the data on 'coefficients' the suggested empirical model for Severity Rate of LTA is obtained as noted below:

$$SRLTA = -451`5.746 - 219.081V3 + 109.835V7 - 332.309V8 + 1532.059V11 + 724.661\,V12 + 457.416V15 - 1312.484V16. \quad \ldots \quad (Eq.\ 5.3)$$

The variables (V3,V7,V8 ....) in the model represents the variant nos. VAR00003, VAR00007 etc. shown in the Table of coefficients (Table - 5.9). Looking at the 't' statistics and significance values in Table - 5.9 it may be noted that VAR 00017 does not fit well in the model and hence not included.

5.2.4 Findings

From the Mode analysis of survey data the following twelve Organizational issues are found to play the most significant role for safety performance improvement as per the perceptions of the respondents :

- Establish Project Safety Policy and Objectives.
- Project safety plan.
- Safety Team comprising representatives of contractors and subcontractors.
- Client's participation in site safety team.
- Selection of Subcontractors based on their past safety record.
- Monitor effectiveness of safety programme through Cost of Quality approach.
- Believe in the fact that most of the accidents occur during normal working hours.

- A systematic approach, defined roles and responsibilities and two-way communication are essential prerequisite for safety excellence.
- Lack of proper training is an impediment for safety excellence.
- Awareness of occupational hazards helps in achieving safety excellence.
- Prioritization of schedule and cost over safety lead to job site accidents.
- Lack of knowledge on safety legislation may lead to continued exposure to unsafe condition.

Besides above the following two organizational issues are found to be significant for safety performance improvement :

- Deficient enforcement of safety is an impediment to safety excellence.
- Workers involvement in implementation of safety procedure and manual helps in achieving excellence.

Of the balance three organizational issues one issue (Problems of wage and job security is a hindrance to safety excellence) is found to have neutral response as far as safety performance is concerned and the other two i.e., (i) Prime contractors appoints subcontractors who are quite capable of meeting technological and legislative requirements of safety and (ii) subcontractors depute qualified safety personnel for implementation of safety programme are totally disagreed.

The study further establishes significant correlations of various organizational issues with the three criteria for safety performance measurement as follows:

(i) Frequency Rate of Lost Time Accident (FRLTA) is found to have significant correlations with the following Organizational issues:

- Deployment of subcontractor with capability to meet legislative and technological requirements of safety goals and objectives (p=0.01).
- Engagement of qualified Safety Personnel by Subcontractor. (p=0. 01).
- Enforcement of safety. (p=0.01). The negative correlation is in conformance to physical observation at sites because the more the enforcement, the lesser is expected to be the FRLTA.

(ii) No significant correlation is observed between FRRI and Organizational issues.

(iii) Severity rate of Lost Time Accident (SRLTA) is found to have significant correlations with the following Organizational Issues :

- Deployment of subcontractor with capability to meet legislative and technological requirements of safety goals and objectives (p=0.01).
- Engagement of qualified Safety Personnel by Subcontractor. (p=0.01).
- Participation of Clients representative in the site safety team (p=0.01).
- Selection of Subcontractors based on their past performance record on safety (p=0.05).
- Believe in the fact that most of the accidents occur during normal working hours rather than extended hours.(p=0.01).

- A systems approach, clear definition of roles and responsibilities and two-way communication is essential for safety excellence. (p=0.05).
- Lack of proper training is a hindrance to safety excellence (p=0.01)
- Enforcement of safety plays a dominant role in safety excellence (p=0.01).

The study also recommends a Linear Regression Model of SRLTA with the various organizational issues as depicted above in Para 5.2. 3.3. The R^2 value of 0.945 suggests a strong fit of the variables (organizational issues) with the outcome performance (SRLTA). However, regression analysis for FRLTA and FRRI with the organizational issues having R-square value of 0.369 and 0.262 do not help us to suggest an empirical model. An improved result is expected with more number of construction organizations coming forward with their responses.

5.3 Behavioural Issues

Responses to behavioral issues are also analyzed for mode, mean and standard deviation, correlation and regression to establish the significant issues and suggest an empirical model for performance measurement. The details of the questionnaire is attached at Annexure –1C.

The analysis of data is done to determine:

(i) The modal response of the construction industry about their perception of the various factors under Behavioural Issues.

(ii) The agreement or otherwise of the analysis based on Mode vs. Mean and Standard Deviation.

(iii) The correlation of safety performance criteria with respect to various behavioral issues and

(iv) Regression of the behavioral issues (considered as independent variables) with the outcome (dependent variable) safety measures.

5.3.1 Results of 'MODE' Analysis

Mode analysis highlights the categorization of issues into three categories viz., Group-1(totally agree), Group-2 (mostly agree) and group –3 (neutral) as explained in para 5.1.1 above. The details are as shown in Table - 5.10.

Table - 5.10 : Classification of Behavioural Issues based on Mode Analysis

Sl.No.	Type of Issues	Group 1 (Q.Nos)	Group 2 (Q.Nos.)	Group 3 (Q.Nos.)	Remarks, if any
1	Behavioral Issues (BI)	1,2,3,6(iii) (Total 4)	5(i),6(i),6(ii) (Total 3)	4,5(ii),5(iii) (Total 3)	

Legend: Group 1: Issues having Likert's Responses '5' (Totally Agree)
Group 2: " " " " '4' (Mostly Agree)
Group 3: " " " " '3' (Neutral/ Agree)

Response 2 & 1 being 'tend to agree' and 'totally disagree' are considered less important for the present analysis.

The details of classification of the Behavioral issues represented by various question nos. in Table-3 are elaborated in Table - 5.11.

Table - 5.11: Classification of Behavioural Issues (Factors) Based on Mode Analysis

S.No.	Survey Question No.	Description
Group-1 : Totally Agree		
01	1.	Top Management considers Safety is a strategic issue and provides active support & resources
02	2	Project/ Construction Manager owns primary responsibility for safety & exhibits compliance to project safety norms
03	3	Necessary PPEs are provided to all employees/ workers and used by them when at work
04	6(iii)	Workers proceeding with the job totally ignoring workplace hazards may lead to accidents.
Group-2 : Mostly Agree		
01	5(i)	Construction accidents occur due to the failure of the worker to identify an unsafe condition (pre-existing or developed during the course of work).
02	6(i)	Awareness about the possible hazards not available
03	6(ii)	Delayed communication/miscommunication of the hazard(s) at work
Group-3: Neutral		
01	4	Whether the workers / employees hesitate to carry on with their work in case any unsafe situation (broken ladder, improper scaffolding, damaged tools etc,) is detected. ?
02	5(ii)	Workers proceeding with the job even after identifying an unsafe condition but prior to its mitigation is a common phenomenon.
03	5(iii)	Indulging into an unsafe act irrespective of the prevailing work environment

5.3.2 Results of analysis of survey data based on mean and standard deviation

The response data are analyzed for mean and standard deviation to check for the central tendency of data response and the findings are as per Table -5.12.

Table - 5.12 : **Results showing Mean & Standard Deviation Questionnaire Survey Response Analysis**

S.No.	Behavioural Issue	Mean	Standard Deviations
1	Top Management considers Safety is a strategic issue and provides active support & resources.	4.60	0.67
2	Project/ Construction Manager owns primary responsibility for safety & exhibits compliance to project safety norms.	4.10	0.95
3	Necessary PPEs are provided to all employees/ workers and used by them when at work.	4.36	0.80
4	Workers hesitate to carry on with their work in case any unsafe condition is detected.	3.74	0.90
5	Construction accidents occur due to workers failure to identify any unsafe condition (pre-existing or developed during the course of work).	4.29	0.66
6	Workers going ahead with the job in spite of an unsafe condition are a common phenomenon at construction sites.	3.67	0.95
7	Workers indulging into unsafe act irrespective of prevailing work environment lead to accident	3.89	0.88
8	Workers unsafe act is due to lack of awareness of possible hazards.	4.22	0.68
9	Delayed communication/ miscommunication of hazards at work may lead to an unsafe act by workers.	4.04	0.42
10	Workers proceeding with the job being totally ignorant of work place hazards may lead to accidents.	4.36	0.92

From a study of the mean values of response, it is observed that the highest value of mean is 4.60 representing "Management view of safety as a strategic issue" is a prime factor. This observation matches with the results of mode analysis as per table – 5.11. Similarly the other observations related to Provision of PPE's and their use by employees appear to be the next important issue (mean 4.36) of safety performance (accident prevention outcome) which also matches with those of mode analysis Table - 5.11.

5.3.3 Correlation Analysis

Behavioural issues are further studied for their correlation with the following three kinds of safety performance measures:

i) Frequency rate of Lost Time Accident (FR LTA) of Q.no 11(i) annexure-1C

ii) Frequency Rate of Recordable Incidences (FRRI) of Q no 11(ii) annexure-1C

iii) Severity Rate of LTA (SR LTA) of Q no 11(iii) annexure-1C.

The 'SPSS' OUTPUT for Correlation (Bivariate) is studied and the results showing various behavioural issues having significant correlation (Pearson 2-tailed) with the above three performance measures at 0.01 level (*) and 0.05 level (**) are highlighted in Table-5.13.

Table - 5.13 : Correlation coefficients of Behavioural issues with Safety Performance Indicators (FR LTA, FR RI & SR LTA)

Sl. No.	Correlation of factors (Q. Nos.) against FR LTA		Correlation of factors (Q. Nos.) against FR RI		Correlation of factors (Q Nos.) against SR LTA	
	Factor	Correlation	Factor	Correlation	Factor	Correlation
1	Q2	-.270*	Q6(iii)	-.537*	--	--
2	Q.4	.386**			Q.4	-.417**
3	--	--	--	--	Q5(i)	.497**
4	Q5(ii)	.387**	-	-	--	--
5	--	--	--	--	Q6(i)	.496**

** Correlation is significant at 0.01 level (2 tailed)

* Correlation is significant at 0.05 level (2 tailed)

5.3.4 Regression Analysis

The Regression analysis is done with the behavioural issue questions no 1 to 6(iii) as independent variables (total 10 nos. of independent variables) identified in the SPSS output as VAR00001 to VAR00010 and Q no. 7 (Safety performance data) as the dependent variable identified as VAR000011. The variables are referred to as V1, V2, V3, etc. in the regression model.

The SPSS output for regression of behavioural issues are studied with regard to the three performance criteria namely FRLTA, FRRI & SRLTA discussed earlier and results are as described below:

5.3.4.1 Regression with Frequency Rate of LTA (FRLTA)

The model summary of regression obtained from SPSS output is as shown in Table – 1 of Annexure - 3.

From Table referred to above it is apparent from the R^2 value (0.406) that the regression fit of behavioural issues with LTA frequency rate is not good enough to suggest a strong empirical Model.

5.3.4.2 Regression with Frequency Rate of Recordable Incidences.

The SPSS output for Regression of FRRI with the various Behavioural issues are studied and the Model summary is shown in Table – 2 of Annexure - 3.

As can be seen from the model summary, R^2 value is 0.559, which is though better than the previous one for FRLTA, is still not good enough for recommendation of an appropriate regression Model of the dependent variable (FRRI) with the behavioural issues.

5.3.4.3 Regression with Severity Rate of LTA (SRLTA)

The response data on Severity Rate of Lost Time Accident (SRLTA) is processed with SPSS-11 software to determine the model summary and identify outlier, if any, through Case wise Diagnostic. The Model summary and Case wise Diagnostic are as per Tables - 3 & 4 of Annexure – 3 respectively.

From the model summary (Table – 3 of Annexure - 3) it may be inferred that the regression fit (R^2 =0.883) of predictor variables versus the output variable (SRLTA) is reasonably strong. Further case wise diagnostics (appended in Table – 4 of Annexure – 3) identifies case no.1 as the outlier.

The regression analysis is also performed after removing case no1 as suggested by case wise diagnostic and improved model summary obtained as shown in Table – 5 of Annexure – 3.

The model summary above shows further improvement in the regression fit indicated by R-square value (R^2=0.942) with the exclusion of outlier. Following from this analysis the coefficients of predictors are determined for development of a suggested model for SRLTA.

The Coefficients of the Predictors in the model are as per Table 5.14.

Table - 5.14 : Model Coefficients of Behavioural issues with SRLTA (after removal of outlier).

Model		Un standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	34170.248	3330.717		10.259	.000
	VAR00001	-2838.365	287.988	-2.269	-9.856	.000
	VAR00002	575.297	132.725	.734	4.334	.000
	VAR00003	-431.100	141.199	-.474	-3.053	.004
	VAR00004	-558.772	51.412	-.651	-10.869	.000
	VAR00005	689.173	209.364	.686	3.292	.002
	VAR00006	-15.980	105.670	-.020	-.151	.881
	VAR00007	-136.357	72.393	-.161	-1.884	.068
	VAR00008	-1101.312	150.907	-1.115	-7.298	.000
	VAR00009	-4032.821	364.645	-1.974	-11.060	.000
	VAR00010	-99.696	47.268	-.143	-2.109	.042

a Dependent Variable: VAR00011

From the data on 'coefficients' the suggested empirical model for Severity Rate of LTA (SRLTA) is obtained as noted below:

$$\text{SRLTA} = 34170.248 - 2838.365V1 + 575.297V2 - 431.100V3 - 558.772V4 + 689.173V5 - 1101.312V8 - 4032.821V9 - 99.696V10 \quad \ldots \ldots \ldots \ldots \ldots \ldots \quad \text{(Eq. 5.4)}$$

Where V1, V2, V3 .... etc. are the predictor variables listed under the coefficients in Table-5.14 as, VAR0001, VAR0002 ... respectively and represent the Q. Nose 1, 2, 3,4, 5(I), 5(ii), 5(iii) 6(I), 6(ii) & 6(iii) as in Annexure-1C. It may be noted here that the variables (V6 & V7 i.e., Q nos5 (ii) and 5(iii) are not included in the model due to their 't' statistics and corresponding significance value shown in the table of coefficients (Table - 5.14)

5.3.5 Findings:

From the Mode analysis of survey data the following seven (out of ten) Behavioural issues are found to play the most significant role for safety performance improvement as per the perceptions of the respondents and the remaining three issues are found to be responded as 'Neutral'.

The mode analysis highlights the following four issues as totally agreed:

(i) Top Management's view of safety as a strategic issue **(Priority 1)**

(ii) Project /construction Managers ownership of responsibility for safety and demonstration of compliance to safety norms.**(Priority 5)**

(iii) Providing of PPE's to all employees and ensures their usage. **(Priority -2)**

(iv) Workers proceeding with the job totally ignoring workplace hazards. **(Priority 2)**

The following three issues are found to be Mostly agreed by the respondents as per mode analysis

- Workers failure to identify any unsafe condition at workplace. **(Priority 3)**
- Lack of awareness of workers about possible hazards, (**Priority 4**) and
- Delayed communication/miscommunication about the hazards at work **(Priority 6)**

The three issues categorized as ' Neutral' includes the following:

(i) Workers hesitation to carry on with the work in case any unsafe condition is detected. **(Priority 8)**

(ii) Workers proceeding with the job in spite of prevailing unsafe condition. **(Priority 9)**

(iii) Workers indulging into unsafe act irrespective of prevailing work environment. **(Priority 7).**

The Priority number mentioned in the parenthesis against the various issues is based on the score of mean (the higher the mean, the higher is the priority) as obtained from the analysis of Mean and Standard deviation in Table 5.12. It is also interesting to note that the three issues categorized as Neutral in the mode analysis are found to have the lower priority numbers. This led us to assume that the outcome of mean, standard deviation analysis is in agreement with mode analysis. Accordingly for the remaining issues only mode analysis is done.

The study further establishes significant correlations of various behavioural issues with the three criteria for safety performance measurement as follows:

(i) Behavioural issues having significant correlation with Safety Performance **(FRLTA)** includes:

- ➢ Project / Construction Manager's owning responsibility for safety and compliance to safety norms (-0.270*, p = 0.05).
- ➢ Workers hesitation to carry on with the work in case any unsafe condition is detected (-0.386**, p = 0.01) and
- ➢ Workers proceeding with the job in spite of an unsafe condition (0.387**, p =0.01)

All the above correlation matches with our physical observation at a construction site. Because the more Project/Construction Managers own the responsibility, the lesser is the chance of an accident, which is signified by the negative correlation. Similarly the remaining two issues with positive correlation is also in agreement with general experience at sites.

(ii) Behavioural issues having significant correlation with other safety performance measure **(FRRI)** includes:

➤ Workers proceeding with the job totally ignoring hazards (-.537**, p=.01)

(iii) Behavioural issues having significant correlation with **SRLTA** includes:

➤ Workers hesitation to carry on with the work in case any unsafe condition is detected (-0.417** p = 0.01). This issue was also significant for FRLTA.

➤ Construction accidents occur due to failure of workers to identify unsafe condition (0.497**, p = 0.01), and

➤ Workers unsafe act is due to lack of awareness of possible hazards (0.496**, p = 0.01).

The correlation coefficients of behavioural issues are also observed to match with practical experience in sites. This is evident from the sign (positive or negative) correlation coefficients.

Regression analysis results pointed to the following findings:

➤ Regression fit of Model for FRLTA and FRRI with the Behavioural Issues is not strong enough to prescribe an empirical model.

➤ However, Regression fit of **Model for SRLTA with behavioural issues is found to be strong enough (R^2 = 0.942) to recommend an empirical model.** Suggested empirical model for Severity Rate of Lost Time

Accidents has been depicted above under Para 5.3.4.3. From the Model coefficients shown in table 5.14, all the predictors are found to be quite significant, excepting VAR00006, having a significance of 0.881, 't' statistics – 0.151 and VAR00007 with a significance of 0.068 and 't' statistics –1.884. These two independent variables (Ref. Q no 5(ii) & 9iii) of Annexure -1C are, therefore, not indicated in the regression model.

CHAPTER –6

ANALYSIS OF PERFORMANCE MONITORING AND MEASUREMENT ISSUES AND IMPLEMENTATION ISSUES

6.0 Introduction

The analysis of Technological, Organizational and Behavioural issues have identified the issues belonging to these categories which are significant from the point of view of achieving safety excellence. The present study has also dealt with the other two types of issues viz., Performance monitoring and measurement issues and Implementation issues.

6.1 Performance Monitoring and Measurement Issues

For the purpose of identifying significant performance monitoring and measurement issues relevant to our Construction Sector, a set of questionnaire (ref. Annexure-1D) is developed and sent to selected Construction Organizations, Engineers & Consultants as detailed under 'survey administration' in chapter- 4 (para- 4.4).

Three stage analysis of data are conducted to determine:

(i) The modal response of the construction industry about their perception of the various factors under performance monitoring and measurement issues.

(ii) The correlation of safety performance indices (FRLTA, FRRI & SRLTA – the dependent variables)) with respect to these issues.

(iii) Regression of these issues (independent variables) with the outcome (dependent variable) safety measures.

The analysis is done using **SPSS 11.0** software.

6.1.1 Results of 'MODE' Analysis

From the mode analysis the Performance Monitoring and Measurement issues are categorized into 3 groups viz., 1, 2 & 3 depending upon the respondents perception of their relative significance for achieving better safety performance as elaborated in Table - 6.1

Table - 6.1: Classification of Performance monitoring and Measurement Issues based on Mode Analysis.

Sl.No.	Type of Issues	Group 1 (Q.Nos)	Group 2 (Q.Nos.)	Group 3 (Q.Nos.)	Remarks, if any
1	Performance monitoring and measurement issues (PMI).	1(i),1(ii),2(i),2(ii), 2(iii), 2(iv),3 (iv) & 4 (Total 8 nos.).	3(i),3(iii),3(v) & 5. (Total 4 nos.)	1(iii), 3(ii) (Total 2 nos.).	Out of 14 Nos. of Issues 12 have been identified as totally agree and Mostly agree together. The remaining 2 are neutral. There is no disagreement with any of the issues.

Legend: Group 1: Issues having Likert's Responses '5' (Totally Agree)
Group 2: " " " " '4' (Mostly Agree)
Group 3: " " " " '3' (Neutral)

Response 2 & 1 being tend to agree and totally disagree are considered less important for the present analysis.

The details of classifications of various Issues in Table-6.1 are explained in Table 6.2.

Table-6.2: Description of Performance Monitoring and Measurement Issues classified in Groups 1,2 &3.

S.No.	Survey Question No.	Description
	GROUP-1 : TOTALLY AGREE	
01	1(i)	Measurement of safety performance based on Loss time accidents.
02.	1(ii)	Measurement of safety performance based on Fatality
03.	2(i)	Daily Inspection of tools & tackles
04	2(ii)	Safety walks downs by Top Management.
05	2(iii)	Root cause analysis of accidents and near misses.
06	2(iv)	(i) Watching behaviour of Workmen, Supervisors and Managers at work for compliance to safety practice.
07	3(iv)	(ii) Rewarding employees and contractors for achieving set goals.
08	4	Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention.
	GROUP-2 : MOSTLY AGREE	
01	3(i)	Poster / banner competition.
02	3(iii)	Celebration of achievement of significant milestone(s).
03	3(v)	Punitive action for habitual offenders of safety Practices.
04	5	Inspection of Personal Protective Equipment
	GROUP-3: NEUTRAL	
01	1(iii)	Measurement of safety performance based on Total incidences.
02	3(ii)	Essay competition on safety issues.

6.1.2 Correlation Analysis

Performance monitoring and measurement factors are analyzed for their correlation (Pearson's 2-tailed, bi- variate) with the following three kinds of safety performance measures:

i) Frequency rate of Lost Time Accident (FRLTA) Q.no. 6(i) Annexure-1D

ii) Frequency Rate of Recordable Incidences (FRRI) Q. no. 6(ii) Annexure-1D

iii) Severity Rate of LTA (SR LTA) Q .no 6(iii) Annexure-1D.

The results showing various Performance monitoring & measurement issues having significant correlation (Pearson's 2-tailed, bi-variate) with the above three performance measures at 0.01 level (**) and 0.05 level (*) are highlighted in Table-6.3.

Table - 6.3 : Performance Monitoring & Measurement. Issues (as per Annex - 1D) having significant correlation with Safety Performance Indicators (FRLTA, FRRI & SRLTA)

Sl. No.	Correlation of factors (Q. Nos) against FR LTA		Correlation of factors (Q Nos) against FR RI		Correlation of factors (Q Nos.) against SR LTA	
	Factor	Correlation	Factor	Correlation	Factor	Correlation
1	Q. 1(i)	-.545**	Q. 1(ii)	-.321*	Q.1(i)	.352*
2	Q3(i)	-.323*	-	-	Q.1(ii)	0.392 **
3	Q 3(ii)	-.322*	-	-	Q. 2(ii)	0.313 *
4	Q. 3(iv)	-.375**	-	-	Q. 3(ii)	0.484 **
5	Q4	-.511**			Q.3 (iv)	0.362*
6			-	-	Q4	.334*

** Correlation is significant at 0.01 level (2 tailed)
* Correlation is significant at 0.05 level (2 tailed)

6.1.3 Regression Analysis

The analysis is done with Q. nos. 1 upto 5 as independent variables identified in the SPSS output as VAR00001 to VAR00014 and Q no. 6 (Safety performance data) as the dependent variable identified as VAR00015.

The regression output of performance monitoring and measurement issues are studied with regard to the three performance criteria namely FRLTA, FRRI& SRLTA and the results are as described below:

6.1.3.1 Regression with Frequency Rate of LTA (FRLTA)

The model summary of regression obtained from SPSS output is shown in Table – 1 of Annexure - 3

From Table referred to above it is apparent that the regression fit (R2 =0.406) of performance monitoring and measurement issues with Frequency Rate of LTA is not enough to suggest a strong empirical Model.

6.1.3.2 Regression with Frequency Rate of Recordable Incidence (FRRI)

The SPSS output for Regression of FRRI with the Performance Monitoring & Measurement issues are analyzed from the Model summary as per Table – 2 of Annexure - 3.

As can be seen from the model summary, R^2 value is 0.559 which is though better than that of FRLTA, the regression fit is still not enough to recommend an empirical model of FRRI with performance monitoring and measurement issues.

6.1.3.3 Regression with Severity Rate of LTA (SR LTA)

The response data on Severity Rate of Lost Time Accident (SRLTA) is processed for regression analysis to determine the model summary and identify outlier, if any, through Case wise Diagnostic. The Model summary is shown in Table – 3 of Annexure - 3.

From the model summary it may be inferred that the regression fit (R^2 =0.887) of predictor variables versus the output variable (SRLTA) is quite strong. Further case wise diagnostics (appended in Table – 4 of Annexure - 3) is used to identify the outlier and run the SPSS programme for obtaining an improved model.

Case wise Diagnostics identified Case number 1 as an Outlier, which is removed from the initial data set, and SPSS was run again for regression analysis. The revised Regression Model Summary obtained is shown in Table – 5 of Annexure – 3.

The model summary above shows a great improvement in the regression fit indicated by R-square value (0.939) with the exclusion of outlier. Following from this analysis the coefficient of predictors is determined for development of a Suggested model for SRLTA.

The Coefficients of the Predictors in the model are as per Table – 6.4

Table - 6.4 : Co-efficients[a] of Performance Monitoring and Measurement issues in Regression Analysis with SRLTA

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	-25777.121	2134.240		-12.078	.000
	VAR00001	3509.282	293.826	2.830	11.943	.000
	VAR00002	-993.431	145.431	-.909	-6.831	.000
	VAR00004	3771.377	315.998	2.541	11.935	.000
	VAR00005	3275.874	282.858	3.825	11.581	.000
	VAR00006	-1446.665	166.077	-1.849	-8.711	.000
	VAR00007	-654.889	61.265	-.584	-10.689	.000
	VAR00009	-1777.139	205.949	-2.014	-8.629	.000
	VAR00010	-2423.271	191.077	-2.324	-12.682	.000
	VAR00011	-2387.149	219.597	-1.821	-10.871	.000
	VAR00012	4383.375	332.030	4.018	13.202	.000
	VAR00014	419.327	161.913	.361	2.590	.014

a. Dependent Variable: VAR00015

From the data on 'coefficients' the suggested empirical model for Severity Rate of LTA is obtained as noted below:

$$\mathbf{SRLTA = -25777.121 + 3509.282\,V1 - 993.431\,V2 + 3771.377V4 + 3275.874V5 - 1446.665V6 - 654.889V7 - 1777.139V9 - 2423.271V10 - 2387.149V11 + 4383.375V12 + 419.327V14} \quad \ldots \ldots \ldots \quad \textbf{(Eq. 6.1)}$$

Where V1, V2, V3 .... Etc are the predictor variables listed under the Model summary in Table -6.8, viz., VAR0001, VAR0002 ... respectively and represent the Q. Nos. 1(i), 1(ii) 2(i), 2(ii), 2(iii), 2(iv) 3(ii), 3(iii), 3(iv) 3(v) and 5 of annexure 1D respectively.

It may be pointed out here that the 't' statistics for all the predictor variables and corresponding significance values indicate that their relative importance in the model is quite useful and fits the model very well.

6.1.4 Findings

From the Mode analysis of survey data the following eight Performances monitoring and measurement issues are found to play the most significant role for safety performance improvement as per the perceptions of the respondents.

- Measurement of safety performance based on Loss time accidents.
- Measurement of safety performance based on Fatality
- Daily Inspection of tools & tackles
- Safety walk downs by Top Management.
- Root cause analysis of accidents and near misses.
- Watching behaviour of Workmen, Supervisors and Managers at work for compliance to safety practice.
- Rewarding employees and contractors for achieving set goals.
- Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention.

Besides above the following four performance monitoring and measurement issues are found to be significant for safety performance improvement:

- Poster / banner competition.
- Celebration of achievement of significant milestone(s).

- Punitive action for habitual offenders of safety Practices.
- Inspection of Personal Protective Equipments

The balance two performance monitoring & measurement issues, viz., (i) Performance measurement based on Total incidences and, (ii) Safety promotion through essay competition are found to have neutral response as far as safety performance is concerned.

The study further establishes significant correlation of various performance monitoring and measurement issues with the three criteria for safety performance measurement as follows:

(i) Frequency rate of Lost Time Accident (FRLTA) is found to have negative correlation with the following Performance Monitoring &measurement issues:

- Measurement of safety performance based on frequency rate and severity rate of Lost time accidents ($p=0.01$).
- Daily Inspection of tools & tackles ($p=0.05$).
- Rewarding employees and contractors for achieving set goals ($p=0.01$)
- Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention ($p=0.01$)

The negative correlation of the above is generally in agreement with the practical observation that betters the safety initiatives; the lesser will be the chances of accidents. The negative correlation is also in agreement with practical experience with regard to accident prevention since with increased supervision by trained and qualified person, the rate of accident is generally found to decline. Same is the case with Mechanical handling equipment with proper certification

(ii) Frequency Rate of Recordable Incidences (FRRI) is observed to have correlations with the only performance monitoring & measurement issue i.e., Measurement of safety performance through frequency rate and severity rate of fatality.

(iii) Severity Rate of Lost time Accident (SRLTA) is found to have correlation with the following six Performance Monitoring & Measurement issues:

- Measurement of safety performance based on frequency rate and severity rate of Lost time accidents (p=0.05).
- Measurement of safety performance through frequency rate and severity rate of fatality.(p=0.01)
- Safety walk downs by Top Management. (p=0.05)
- Safety promotion through essay competition on safety issues. (p=0.01)
- Safety promotion through rewarding of employees and contractors for achievement of goals. (p=0.05).
- Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention (p=0.05).

The correlation analysis results show skew ness in some cases. This may be due to various reasons like lesser number of response, partial response and inaccurate information with regard to performance data. This may be overcome with more and more voluntary participation of the construction industry with proper recording of data.

The study also recommends a linear regression Model of SRLTA with the various performance monitoring and measurement issues as depicted above in Para 6.1.3.3. The R^2 value of 0.939 suggests a strong fit of the variables (performance monitoring & measurement issues) with the outcome performance (SRLTA). Likewise regression analysis of Frequency Rate of Recordable Incidence (FRRI) with the performance monitoring & measurement issues are also studied. The R^2 value of 0.559 do not lead us to recommend a linear Regression model of FRRI with Performance monitoring and measurement issues.

The Regression analysis for performance monitoring and measurement issues with Frequency rate of lost time accidents shows a R^2 value of 0.406 and therefore, an effective model of regression fit could not be recommended.

The present study recommends a model for monitoring of Severity rate of lost time accident which may be used for benchmarking with similar organizations and also serve as a measure of continuous performance improvement.

The proposed models may be improved further through wholehearted participation of construction organizations of all categories like, large, medium and small so that a good number of completed responses are received for analysis.

The models can also be used as a tool for continuous improvement through quantifiable performance measure.

6.2 Implementation Issues

For the purpose of identifying significant Implementation issues relevant to our Construction Sector, a set of questionnaire (ref. Annexure-1E) is developed and sent to selected Construction Organizations, Engineers & Consultants as detailed under 'survey administration' in chapter - 4 (para- 4.4).

Three stage analysis of data are conducted to determine:

(i) The modal response of the construction industry about their perception of the various factors under Implementation issues.

(ii) The correlation of safety performance indices (FRLTA, FRRI & SRLTA – the dependent variables)) with respect to these factors.

(iii) Regression of these factors (independent variables) with the outcome (dependent variable) safety measures.

The analysis is done using **SPSS 11.0** software.

6.2.1 Results of 'MODE' Analysis

Using SPSS 11 the survey data are analyzed for mode of response.

From the mode analysis the `Implementation Issues are categorized into three groups viz., 1, 2 & 3 depending upon the respondents perception of their significance for achieving better safety performance as elaborated in Table -6.5

Table - 6.5 : Classification of Implementation Issues based on Mode Analysis.

Sl.No.	Type of Issues	Group 1 (Q.Nos)	Group 2 (Q.Nos.)	Group 3 (Q.Nos.)	Remarks, if any
1	Implementation Issues (II)	1(i),(iii),(iv),(vii),(ix),(x) (xi),(xii), 2(i),(ii),(iii),(iv). (Total 12)	1(ii),(v),(vi),(viii), (xiii),(xiv) (Total 6).	0	Nil.

Legend: Group 1: Issues having Likert's Responses '5' (Totally Agree)
Group 2: " " " " '4' (Mostly Agree)
Group 3: " " " " '3' (Neutral / Agree)

Response 2 & 1 being 'tend to agree' and 'totally disagree' are considered less important for the present analysis.

A significant observation of the above analysis is the fact that, of the total 18 issues for implementation 12 issues are totally agreed by the respondents where as remaining 6 issues are mostly agreed. None of these issues are considered as neutral and/or totally disagreed. This in essence implies the respondents consider these 18 issues of implementation are quite important for accident prevention.

The details of the issues classified in Groups 1, 2 & 3 in Table – 6.5 are elaborated in Table - 6.6.

Table - 6.6 : Description of Implementation Issues classified in Groups 1,2 &3

S.No.	Survey Question No.	Description
Group-1 : Totally Agree		
01	1.(i)	Establishment of pre-set goals & objectives for every project.
02	1(iii)	Prior selection of trained & qualified safety professionals.
03	1(iv)	Safety training & orientation programme .
04	1(vii)	Establishment of procedure for emergency for medical and security response.
05	1(ix)	Insisting for pre-task planning, job safety analysis & hazard identification
06	1(x)	Development of procedure for work permit to tackle unsafe conditions, if any
07	1(xi)	Project Safety Committee comprising representatives of Clients, Contractors and Subcontractors
08	1(xii)	Positive promotion of good safety culture
09	2(i)	Post completion safety record to highlight significant achievements
10	2(ii)	Post completion safety record to highlight lessons learnt.
11	2(iii)	Post completion safety record to highlight rewarding the achievers
12	2(iv)	Document statistics for future research
Group-2 : Mostly Agree		
01	1(ii)	Arranging Safety kick-off meeting prior to start of the project.
02	1(v)	Approval of HSE Plan of Contractors/Subcontractors.
03	1(vi)	Decide Policy & Practices related to safety audit, inspection accident/ near-miss investigation reporting.
04	1(viii)	Establishment of Procedures for tracking safety reports & statistics for achieving continued improvement
05	1(xiii)	Continuous monitoring of workers behaviour to prevent unsafe acts.
06	1(xiv)	Disciplinary action for recurrent unsafe acts
GROUP-3: NEUTRAL ----- NIL		

A quick glance at table – 6.6 shows that all the 18 issues taken up for the survey were positively supported by the respondents as important factors for safety performance. However a correlation analysis of these issues (independent variables) against the safety performance results (FRLTA,FRRI & SRLTA) is expected to further elaborate the observations.

6.2.2 Correlation Analysis

Implementation issues are further studied for their correlation with the following three kinds of safety performance measures:

i) Frequency rate of Lost Time Accident **(FR LTA)** of Q.no. 3(i) of Annexure -1E

ii) Frequency Rate of Recordable Incidences **(FRRI)** of Q no. 3(ii) of Annexure -1E

iii) Severity Rate of LTA (**SR LTA**) of Q no. 3(iii) of Annexure -1E.

The 'SPSS' OUTPUT for Correlation (Bivariate) is studied and the results showing various Implementation issues having significant correlation (Pearson 2-tailed) with the above three performance measures at 0.01 level (**) and 0.05 level (*) are highlighted in Table - 6.7.

Table - 6.7 : Correlation Coefficients of Implementation Issues with Safety Performance Indicators (FR LTA, FR RI & SRLTA)

Sl. No.	Implementation Issues	Pearson Correlation with		
		FR LTA	FR RI	SR LTA
1	Establishment of pre-set goals & objectives for every project	.319*	-.302*	.319*
2	Prior selection of trained & qualified safety professionals.	-.459**	-	-.459**
3	Safety training & orientation programme.	-.292*	-	-.292*
4	Decide Policy & Practices related to safety audit, inspection accident/ near-miss investigation & reporting.	-	-.446**	-
5	Insisting for pre-task planning, job safety analysis & hazard identification.	.424**	-	.424**
6	Development of procedure for work permit to tackle unsafe conditions, if any.	-	-.402**	-
7	Continuous monitoring of workers behaviour to prevent unsafe acts.	.778**	-	.778**
8	Disciplinary action for recurrent unsafe acts.	.411**	-	.411**
9	Post completion safety report to highlight rewarding the achievers	-.351*	-.337*	-.351*

**Correlation is significant at 0.01 level (2- tailed).
*Correlation is significant at 0.05 level (2-tailed)

6.2.3 : Regression Analysis

The Regression analysis is done with the Implementation issue questions no 1(i) to 1(xiv) & 2(i) to 2(iv) as independent variables (total 18 nos. of independent variables) identified in the SPSS output as VAR00001 to VAR00018 respectively and Q no. 3(i),(ii)&(iii) (Safety performance data) as the dependent variable identified as VAR00019. The variables are referred to as V1, V2, V3... etc. in the regression model.

The SPSS output for regression of Implementation issues are studied with regard to the three performance criteria namely FRLTA, FRRI & SRLTA discussed above and results are as described below:

6.2.3.1 Regression with frequency rate of LTA (FRLTA)

The model summary of regression obtained from SPSS output is as shown in Table – 1 of Annexure – 3.

Referring to the Table – noted above it is apparent from the R^2 value (0.432) that the regression fit of Implementation issues with Frequency Rate of LTA is not strong enough to suggest an empirical Model. Similar conclusion can be derived from the Regression model coefficients shown in Table – 6.8.

Table – 6.8 : Regression coefficients of Implementation issues with FRLTA

		Un standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	37.648	26.115		1.442	.157
	VAR00001	-3.806	3.391	-.657	-1.122	.268
	VAR00002	-.483	3.604	-.068	-.134	.894
	VAR00007	-7.325	9.981	-.710	-.734	.467
	VAR00008	2.780	3.078	.438	.903	.371
	VAR00009	-5.195	3.866	-.709	-1.344	.186
	VAR00010	-3.120	3.489	-.299	-.894	.376
	VAR00013	10.018	11.555	.866	.867	.391
	VAR00014	-4.680	3.954	-.538	-1.184	.243
	VAR00016	.536	3.091	.047	.173	.863
	VAR00017	-1.116	3.554	-.126	-.314	.755
	VAR00018	5.104	5.348	.625	.954	.345

a Dependent Variable: VAR00019

From Table-6.8 the 't' statistics shows that the predictors in the regression model do not lead us to recognize them as useful, because for usefulness of the predictors, the 't' statistics generally lies well below -2 or above +2 which is not the case as per the findings. Similarly the 'significance' values shown are also indicative of the fact that the predictors usefulness is not there (a good value of Sig. is below 0.05).

6.2.3.2 : Regression with Frequency Rate of Recordable Incidences (FRRI).

The SPSS output for Regression of FRRI with the various Implementation issues are also obtained as can be seen from the Model summary as per Table – 2 of Annexure – 3.

As can be seen from the model summary, R^2 value is 0.593, which is though better than the previous one for FRLTA, is still not good enough for an appropriate regression fit between the variables. The same conclusion can be arrived at form a review of 't' statistics & significance values of model coefficients shown in Table - 6.9.

Table-6.9 : Regression coefficients of Implementation issues with FRRI

		Un standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	13.588	15.936		.853	.400
	VAR00001	-.981	.582	-.320	-1.686	.101
	VAR00002	-.692	1.237	-.214	-.560	.579
	VAR00005	-2.249	.759	-.461	-2.965	.006
	VAR00007	2.803	2.619	.507	1.070	.292
	VAR00008	-.341	1.624	-.106	-.210	.835
	VAR00010	-2.338	1.025	-.569	-2.282	.029
	VAR00014	-.675	1.872	-.149	-.360	.721
	VAR00015	.136	.866	.031	.157	.877
	VAR00018	2.010	1.478	.435	1.360	.183

a Dependent Variable: VAR00019

For a useful predictor in the model the 't' value is supposed to be much higher than +2 or lower than – 2. From the present data therefore an empirical model for regression of Implementation issues with Frequency Rate of Recordable incidence (FRRI) cannot be recommended.

6.2.3.3 : Regression with Severity Rate of LTA (SR LTA)

The response data on Severity Rate of Lost Time Accident (SRLTA) are processed with SPSS software to determine the model summary and identify outlier, if any, through Case wise Diagnostic (3-sigma limits). The Model summary and Case wise Diagnostic are as per Tables – 3 & 4 respectively of Annexure – 3.

From the model summary it may be inferred that the regression fit (R^2 = 0.887) of predictor variables of the implementation issues with SRLTA is reasonably strong enough to recommend an empirical model. Further Case wise diagnostic shown in Table – 4 of Annexure –3 is used to identify outliers if any, so as to develop an improved model.

Case wise diagnostics has identified Case no. 1 as an outlier.

The regression analysis is again performed after removing Case no.1 as suggested by case wise diagnostic and revised Regression Model summary is obtained as shown in Table – 5 of Annexure - 3.

The model summary above shows a great improvement in the regression fit indicated by R-square value (R^2=0.939) with the exclusion of outlier. No further outlier was detected in the present regression. A suitable model can be recommended with the present R^2 value of 0.939. However, in search of a further improvement of the model, the analysis is performed once again with case wise diagnostic within 2-sigma limits (in place of 3 - sigma initially taken). With this change a revised case wise diagnostic is obtained which indicates Case nos. 1,2& 4 as outliers as shown in Table - 6.10.

Table - 6.10 : Case wise Diagnostics (2- Sigma) Regression of Implementation Issues with SRLTA

Case Number	Std. Residual	VAR00019	Predicted Value	Residual
1	3.965	2976.00	1716.6000	1259.4000
2	-2.262	998.00	1716.6000	-718.6000
4	-2.382	960.00	1716.6000	-756.6000

a. Dependent Variable: VAR00019

Further regression analysis is done after removal of the outliers (Case nos. 1,2&4) and revised model summary is obtained as shown in Table - 6.11

Table - 6.11 : Model Summary of Regression of Implementation Issues with SRLTA (after removal of Case nos.1,2&4)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.983	.966	.955	161.31030

a. Predictors: (Constant), VAR00018, VAR00013, VAR00010, VAR00002, VAR00016, VAR00008, VAR00007, VAR00005, VAR00009, VAR00017, VAR00014
b Dependent Variable: VAR00019

A significant improvement of the regression fit is thus obtained in the present analysis with R^2 value of 0.966. Based on this regression a suggested empirical model for severity rate of LTA is developed with the model coefficients as per Table – 6.12.

Table - 6.12 : Model Coefficients of Implementation Issues wit SRLTA after removal of outliers (2-Sigma limits).

		Un standardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1574.740	768.902		2.048	.049
	VAR00002	637.106	140.942	.651	4.520	.000
	VAR00005	709.343	91.707	.680	7.735	.000
	VAR00007	-1118.213	201.126	-.706	-5.560	.000
	VAR00008	-9.540E-02	102.022	.000	-.001	.999
	VAR00009	-232.933	156.311	-.233	-1.490	.146
	VAR00010	-209.458	103.909	-.172	-2.016	.052
	VAR00013	1827.038	340.916	1.153	5.359	.000
	VAR00014	-96.731	216.887	-.089	-.446	.659
	VAR00016	-874.243	104.903	-.572	-8.334	.000
	VAR00017	-1994.237	117.804	-1.532	-16.928	.000
	VAR00018	1159.895	161.848	1.110	7.167	.000

a Dependent Variable: VAR00019

The regression Model for SRLTA with Implementation Issues developed in this analysis is as noted below:

SRLTA = 1574.740 + 637.106V2 + 709.343V5 - 1118.213V7 - 209.458V10 + 1827.038V13 - 874.243V16 - 1994.237V17 + 1159.895V18 ... ... (Eq. 6.2)

From Table - 6.12 it is observed that the predictors include the constant and 11other variables (implementation issues). However in our proposed model noted above three variables V8, V9 & V14 have not been included. This is due to the fact that the 't' statistics and significance values do not justify them to be good predictors.

In the above model the predictor variables V2, V5,V7,V10,V13,V16,V17& V18 denote implementation issues represented by question nos1(ii),1(v),1(vii),1(x),1(xiii),2(ii),2(iii)&2(iv) respectively as described in Annexure-1E.

6.2.4 : Findings:

6.2.4.1 : The important findings of the mode analysis are as follows:

(i) All the eighteen implementation issues in the questionnaire (Annexure -1E) is found to be very important with 12 of them being 'totally agreed' and remaining 6 'mostly agreed' by the respondents perception.

(ii) Classification of implementation issues in groups-1 (totally agree) and 2 (mostly agree) are shown in Table - 6.5. Where as 12 issues are classified in group-1 remaining 6 issues is classified in group-2 and no issue is found to belong to group-3 (neutral).

6.4.2.2. Correlation Analysis

The study further establishes significant correlation of various implementation issues with the three criteria for safety performance measurement as follows:

(i) Results of correlation analysis indicated in Table - 6.7 identify nine issues having significant correlation with one or more of the three safety performance criteria (FRLTA, FRRI & SRLTA). Six out of these issues were found to be significant at 99% confidence level (p=0.01) and the remaining three at 95% confidence level (p=0.05)

The correlation analysis also led to the finding that two of the issues viz., (a) establishment of pre-set goals and objectives for every project, and (b) post completion safety report to highlight rewarding the achievers are the common issues having significant correlation with all the three performance criteria (FRLTA, FRRI& SRLTA) considered in the study.

Another important observation of the correlation study is that of the nine issues identified as having significant correlation with the safety performance criteria, six belong to Group 1 (totally agree) and remaining three to group-2 (mostly agree) as per the' mode' analysis of survey response data (refer Table - 6.6) thus making the study results of Mode analysis to conform to that of correlation analysis.

The correlation analysis also leads to the following observations:

(i) The Frequency rate of Lost Time Accident (FRLTA) and Severity rate of Lost time accident (SRLTA) were found to have negative correlation with the three issues namely,

- Prior selection of trained & qualified safety professionals (p=0.01)
- Safety training & orientation programme (p=0.05)
- Post completion safety report highlighting rewarding of the achievers.(p=0.05)

The following four issues show some skewness in correlation with FRLTA and SRLTA :

- Establishment of pre-set goals & objectives for every project (p=0.05).

- Insisting for pre-task planning, job safety analysis & hazard identification (p=0.01).
- Continuous monitoring of workers behaviour to prevent unsafe acts (p=0.01) and
- Disciplinary action for recurrent unsafe acts (p=0.01).

The observation may be improved with more number of responses along with safety performance statistics.

(ii) Similarly the Frequency rate of recordable incidences (FRRI) were found to have negative correlation with the following four issues:

- Establishment of pre-set goals & objectives for every project (p=0.05)
- Decide Policy & Practices related to safety audit, inspection accident/ near-miss investigation & reporting (p=0.01).
- Development of procedure for work permit to tackle unsafe conditions, if any (p=0.01)
- Post completion safety report to highlight rewarding the achievers (p=0.05)

There was no issue identified which has a positive correlation with FRRI.

6.4.2.3 : Regression Analysis results pointed to the following:

- Regression fit of Model for FRLTA (R^2 =0.432) with Implementation Issues is not strong enough to prescribe an empirical model.

- Similarly Regression fit of Model for FRRI (R^2=0.539) with Implementation issues is also not strong enough to suggest an empirical model.
- However, Regression fit of Model for SRLTA with Implementation issues was found to be very good (R2=0.966) to recommend an empirical model. Suggested empirical model for Severity Rate of Lost Time Accidents has been depicted above in para6.2.3.3. after the Table6.22. From the Model coefficients shown in Table 6.12, it is noted that out of 12 predictors including the constant, three predictors were not found to be quite significant as can be seen from their 't' statistics and 'Sig' value.

These three predictors include:

- VAR00008: Establishment of Procedures for tracking safety reports & statistics for achieving continual improvement.
- VAR00009: Insisting for pre-task planning, job safety analysis & hazard identification.
- Var00014: Disciplinary action for recurrent unsafe acts

These three predictors are therefore, not included in the suggested model of SRLTA.

CHAPTER – 7

IMPACT OF SAFETY ISSUES ON CONSTRUCTION SAFETY PERFORMANCE

7.0 Introduction

The analysis of technological, organizational, behavioural, performance monitoring & measurement and implementation issues has identified various significant factors affecting safety performance at construction site. In this chapter the combined effect of all the safety issues are studied.

The survey response data is collected as described under 'Methodology' in Chapter –4.The questionnaire used for data collection is appended in Annexure-1.

The analysis is done in the same way as has been done for the other issues which includes:

- Mode analysis: To identify the issues as per their mode of response in a five point likert's scale and categorize them into Groups 1,2 &3 as detailed below.
- Correlation analysis: To establish the issues having significant correlation with the Performance criteria (FRLTA, FRRI & SRLTA) considered for the present study.

- Regression analysis: To study the regression fit between the outcome performance variables (dependent variable) with the various safety issues (independent variables).

The details of analysis are appended below.

7.1 Analysis of Mode of Response

Using SPSS 11 the survey data are analyzed for mode of response. From the mode analysis the Issues are categorized into three groups depending upon the respondents perception of its significance for achieving better safety performance. The details of the groups are elaborated below:

Group 1: Issues having Likert's Response '5' (Totally Agree)

Group 2: " " " " '4' (Mostly Agree)

Group 3: " " " " '3' (Neutral/ Agree)

Response 2 & 1 being 'tend to agree' and 'totally disagree' are considered less important as far as their significance to safety performance is concerned. These responses are not considered for the present analysis. The details of classification of the various issues are elaborated in Table- 7.1 and the respective question numbers are as per Annexure-1.

Table - 7.1: Classification of Safety Issues (Factors) Based on Mode Analysis

Sl. No.	Type of Issues	Group 1 (Survey Q.Nos.)	Group 2 (Survey Q.Nos.)	Group 3 (Survey Q.Nos.)
1.	Technological	8,10(v). Total 2nos.	1,4,7,10(i), 10(ii) 10(iii), 10(iv) Total 7nos	2,3,5,6,10(vi) Total 5nos
2.	Organizational	11,12,15,16,18,20,22,23(i) , 23(ii), 23(V), 23(VII), 23(VIII), Total 12 nos.	23(iii), 23(vi), Total 2 nos.	23(iv) Total 1 no.
3.	Behavioural	24,25,26,29(III) Total 4nos	28(i), 29(i), 29(ii) Total 3nos.	27,28(ii), 28(iii) Total 3 nos
4.	Performance Monitoring & Measurement	30(I), 30(II),31(i)31(ii), 31(iii 31(iv), 32(iv)&33 total 8 nos.	32(i),32(iii),32(v), 34 Total 4nos.	30(iii),32(ii). Total 2nos
5.	Implementation	35(i),35(ii),35(iii),35(iv),35(v), 35(vi), 35(viii), 35(ix), 35(x), 35(xi), 35(xii) 35(xiv), 36(i), 36(ii) Total 14nos	35(vii), 35(xiii), 36(iii), 36(iv) Total 4nos	--
	Grand Total	40	20	11

From Table-7.1 it is observed that out of 74 issues (including sub-issues) taken for the study a total of 60 issues are agreed by the respondents to be quite significant for accident prevention. Of these 60 issues 40 are totally agreed by the respondents and remaining 20 are mostly agreed as significant. The mode analysis also reveals that issues represented by Question nos. 13 &14 both Organizational issues are totally disagreed by the respondent's mode of response. Similarly Technological issue Question no. 9 is observed to as 'tend to agree' as per the mode analysis.

7.2 : Correlation Analysis

The response data are analyzed for correlation with the three safety performance criteria, i.e., FRLTA, FRRI& SRLTA and the results are shown in Table-7.2.

Table - 7. 2 Correlation coefficients of Safety issues w.r.t. Safety Performance criteria (FRLTA, FRRI, SRLTA)

Sl. No.	Issue description (Survey Q. Nos. as per annexure-1)	Correlation Coefficient (Pearson 2-tailed)			Remarks (Issue classification)
		FRLTA	FRRI	SRLTA	
1	Q. –1	-	.327*	-	Technological
1	Q. 2	-	-	.271*	Technological
2	Q.4	-	-.342*		Technological
3	Q.5	-	-	.375*	Technological
4	Q.6	-	-	.443**	Technological
5	Q.8	-.383**	-	-	Technological
6	Q.10 (ii)	-	-	-.319*	Technological
7	Q.10 (v)	-	-	.364**	Technological
8	Q.10 (vi)	-.315*	-	.318*	Technological
9	Q.13	.378**	-	-.392*	Organizational
10	Q.14	.564**	-	-.362**	Organizational
11	Q.16	-	-	.381**	Organizational
12	Q.18	-	-	.380**	Organizational
13	Q.23 (i)	-.291*	-	.329*	Organizational
14	Q.23 (ii)	-	-	.299*	Organizational
15	Q.23 (iii)	-	-	.467**	Organizational

Sl. No.	Issue description (Survey Q. Nos. as per annexure-1)	Correlation Coefficient (Pearson 2-tailed)			Remarks (Issue classification)
16	Q.23 (v)	-.304*	-	-.427**	Organizational
17	Q.24	-	-	-.319**	Behavioural
18	Q.27	.400**	-	-.398**	Behavioural
19	Q.28 (i)	-.	-	.484**	Behavioural
20	Q.28 (ii)	.399**	-	-	Behavioural
21	Q.29 (i)	-	-	.493**	Behavioural
22	Q.29 (iii)	-	-.537**		Behavioural
23	Q.30 (i)	-.552**		.347**	Perform. Monitoring & Measurement
24	Q.30 (ii)	-	-.321*	.406**	Perform. Monitoring & Measurement
25	Q.32 (i)	.276*	-	-	Perform. Monitoring & Measurement
26	Q.32 (ii)	-.359**	-	.516**	Perform. Monitoring & Measurement
27	Q.32 (iv)	-.346	-	.318*	Perform. Monitoring & Measurement
28	Q.33	-.500**	-	.313*	Perform. Monitoring & Measurement
29	Q.35 (i)	-.286*	-.302*	.334*	Implementation
30	Q.35 (ii)	-.445**	-	-	Implementation
31	Q.35 (iii)	-	-	-.467**	Implementation
32	Q.35 (iv)	-	-	-.298*	Implementation

Sl. No.	Issue description (Survey Q. Nos. as per annexure-1)	Correlation Coefficient (Pearson 2-tailed)			Remarks (Issue classification)
33	Q.35 (v)	-.297*	-	-	Implementation
34	Q.35 (vi)	-.419**	-.446**	-	Implementation
35	Q.35 (ix)	-.467**	-	.403**	Implementation
36	Q.35 (x)	-	-.402**	-	Implementation
37	Q.35 (xiii)	-.345**	-	.792**	Implementation
38	Q.36 (iii)	-.379**	-.331*		Implementation

**Correlation is significant at 0.01 level (2- tailed)
*Correlation is significant at 0.05 level (2-tailed)

The details of findings of correlation analysis are appended in para 7.4

7.3 Regression Analysis

The regression analysis is done for the response data with respect to the criteria (FRLTA, FRRI & SRLTA) considered for the present research. The regression model summary for FRLTA and FRRI are shown in Table- 7.3 & 7.4 respectively.

Table - 7.3: Regression Model Summary of the Safety issues with FRLTA

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.578	.334	.178	4.76805

Predictors: (Constant), VAR00074, VAR00045, VAR00022, VAR00043, VAR00026, VAR00053, VAR00032, VAR00002
B Dependent Variable: VAR00075

Table-7.4: Regression Model Summary of the safety issues with FRRI

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.512	.262	.098	2.52264

Predictors: (Constant), VAR00074, VAR00031, VAR00022, VAR00007, VAR00019, VAR00030
B Dependent Variable: VAR00075

From a look at the Tables 7.3, & 7.4 it is evident that R^2 value of regression analysis with FRLTA and FRRI as dependent variables are quite small i.e., 0.334 and 0.262 respectively. This signifies the fact that a reliable regression model of the safety issues with respect to FRLTA and FRRI cannot be arrived at.

The Regression model summary for SRLTA and corresponding case wise diagnostics obtained from the regression analysis is shown at Tables 7.5 and 7.6 below.

Table - 7.5 : Regression Model Summary of the safety issues with SRLTA

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945	.893	.868	315.08147

Predictors: (Constant), VAR00074, VAR00045, VAR00022, VAR00043, VAR00026, VAR00053, VAR00032, VAR00002
B Dependent Variable: VAR00075

Table - 7.6 : Case wise Diagnostics for Regression Analysis of Safety Issues with SRLTA

Case Number	Std. Residual	VAR00075	Predicted Value	Residual
1	3.997	2976.00	1716.6000	1259.4000
17	-3.381	519.00	1584.4294	-1065.4294
18	-3.400	513.00	1584.4294	-1071.4294
19	-3.207	574.00	1584.4294	-1010.4294
44	5.067	132.59	-1463.8213	1596.4113
45	4.956	97.86	-1463.8213	1561.6813

A Dependent Variable: VAR00075

From a review of results of Regression analysis for SRLTA shown in Table7.5 the R^2 value (0.893) is found to be quite good for suggesting a Regression Model. However the case wise diagnostics (Table-7.6) obtained from the regression analysis shows that Case nos.1, 17,18,19,44 & 45 are outliers. These six cases are removed from the data set and SPSS for Regression is run again. The Revised Model summary of SRLTA with removal of above six outliers is obtained as shown in Table - 7.7

Table - 7.7: Regression Model Summary of the issues with SRLTA (after removal of 6- outliers).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.972	.945	.932	205.44003

Predictors: (Constant), VAR00074, VAR00045, VAR00022, VAR00043, VAR00026, VAR00053, VAR00032, VAR00002
B Dependent Variable: VAR00075.

Results of regression analysis with the removal of six outliers shows a great improvement in the regression-fit with R^2 = 0.945. The R^2 value of regression analysis with SRLTA as the dependent variable is 0.945, which is considered very well and provides a better and dependable Model of regression fit of the various issues (the independent variables) with SRLTA. The results lead us to recommend a Model for SRLTA as dependent variable with respect to safety issues as independent issues with the help of the coefficients of the predictors obtained from the same analysis as noted in table7.8.

Table - 7.8: Coefficients of Safety Issues in Regression Analysis with SRLTA

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	-8612.017	741.746		-11.610	.000
	VAR00002	1021.904	103.195	.837	9.903	.000
	VAR00022	262.777	58.581	.258	4.486	.000
	VAR00026	129.311	112.246	.074	1.152	.257
	VAR00032	-433.116	90.584	-.343	-4.781	.000
	VAR00043	660.115	82.178	.535	8.033	.000
	VAR00045	-198.074	53.264	-.288	-3.719	.001
	VAR00053	1507.725	137.425	.839	10.971	.000
	VAR00074	-793.595	83.159	-.675	-9.543	.000

a Dependent Variable: VAR00075

The recommended regression model of SRLTA with the safety issues can be depicted with the help of coefficient of predictors from Table-7.8 as below:

$$\mathbf{SRLTA = -7964.825 + 1042.411V2 + 227.793V22 - 494.639V32 + 671.575V43 - 214.359V45 + 1443.187V53 - 687.439V74 \quad (Eq.\ 7.1)}$$

In the above model V2, V22, V32, V43, V45, V53 and V74 correspond to VAR nos. 00002, 00022 etc respectively noted in the SPSS output for regression. These variables in the model represent various issues against survey Q. Nos. as per Annexure-1 such as:

V2 represents Q2, V22 represents Q18,V32 represents Q23(viii),V43 represents Q30(i),V45 represents Q no.30(iii),V53 represents Q no 32(iv)& V74 represents Q no 36(iv) respectively.

The goodness of the model is also established from the 't' – statistics obtained from SPSS output for co-efficient (refer Table-7.8). It is observed that the 't' statistics and corresponding significant levels for the various predictors in the model are quite good except for VAR 000 26 {Question No. 23(ii)} for which the 't' statistics is 0.358. This issue is therefore not included in the SRLTA Model shown above.

Case wise diagnostics obtained from the current regression (after removal of 6 outliers in the initial regression) shows five outliers represent by Case nos. 1,17,18,19,44 & 45 as can be seen from Table-7.9 .

Table - 7.9: Case wise Diagnostics for Regression Analysis of Safety Issues with SRLTA

Case Number	Std. Residual	VAR00075	Predicted Value	Residual
1	3.997	2976.00	1716.6000	1259.4000
17	-3.381	519.00	1584.4294	-1065.4294
18	-3.400	513.00	1584.4294	-1071.4294
19	-3.207	574.00	1584.4294	-1010.4294
44	5.067	132.59	-1463.8213	1596.4113
45	4.956	97.86	-1463.8213	1561.6813

a Dependent Variable: VAR00075

The above five outliers are also removed from the data set and SPSS was run again in search of a better regression fit. The Model summary obtained in this iteration is shown in Table 7.10.

Table - 7.10: Revised Regression Model Summary of the Issues with SRLTA (after removal of 5- outliers from the second iteration).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.972	.945	.931	208.59652

a Predictors: (Constant), VAR00074, VAR00045, VAR00034, VAR00040, VAR00050, VAR00026, VAR00008, VAR00070
b Dependent Variable: VAR00075

A comparison with the Regression Model summary reveals that the revised model summary in Table - 7.10 obtained after removal of the five outliers in the second iteration does not show any change in the R^2 value, which is 0.945 in both the cases. However in the last iteration the Standard Error of the estimate is found to increase from 205.44003 in Table - 7.7 to 208.59652 in Table - 7.10. It is therefore evident that the model obtained from the second iteration (Eq. 7.1) with Coefficients of predictors taken from Table - 7.8 is a better case and is recommended in this study.

7.4 Findings

The findings of analysis of mode, Correlation and Regression are appended below.

7.4.1 Mode Analysis

The 'Mode' analysis results indicate that out of 74 issues considered as having impact on the safety performance outcome, 40 issues (technological –2, organizational – 12, behavioural – 4, performance monitoring – 8 &

implementation – 12) are responded as "totally agreed". Further 20 issues (technological – 7, organizational – 2, behavioural – 3, performance monitoring – 4 & implementation –4) are responded as "mostly agreed". Again 11 issues (technological – 5, organizational – 1, behavioural – 3 & performance monitoring –2) are responded as "neutral". The detailed break up is shown in Table - 7.11

The Summary of frequency distribution of the various issues in categories 'Totally agree', 'Mostly agree', 'Neutral' and 'others' (including 'Tend to agree' and 'Totally disagree') are shown in Table - 7.11 The results are shown graphically in Figures 7.11a, 7.11b, 711c and 7.11d respectively.

Figure 7.11e gives the Pie chart showing the proportion of the issues belonging to above categories.

Table - 7.11 : Table showing Summary of Frequency Distribution of various Issues in Groups based on Mode Analysis

Issue Type	Totally Agree (Group -1)	Mostly Agree (Group - 2)	Neutral (Group – 3)	Others *	Total
Technical	2	7	5	1	15
Organizational	12	2	1	2	17
Behavioural	4	3	3	NIL	10
Perf, Mon. & Measurement	8	4	2	NIL	14
Implementation	14	4	NIL	NIL	18
Total	**40**	**20**	**11**	**3**	**74**

- Includes totally Disagree & Tend to Agree.

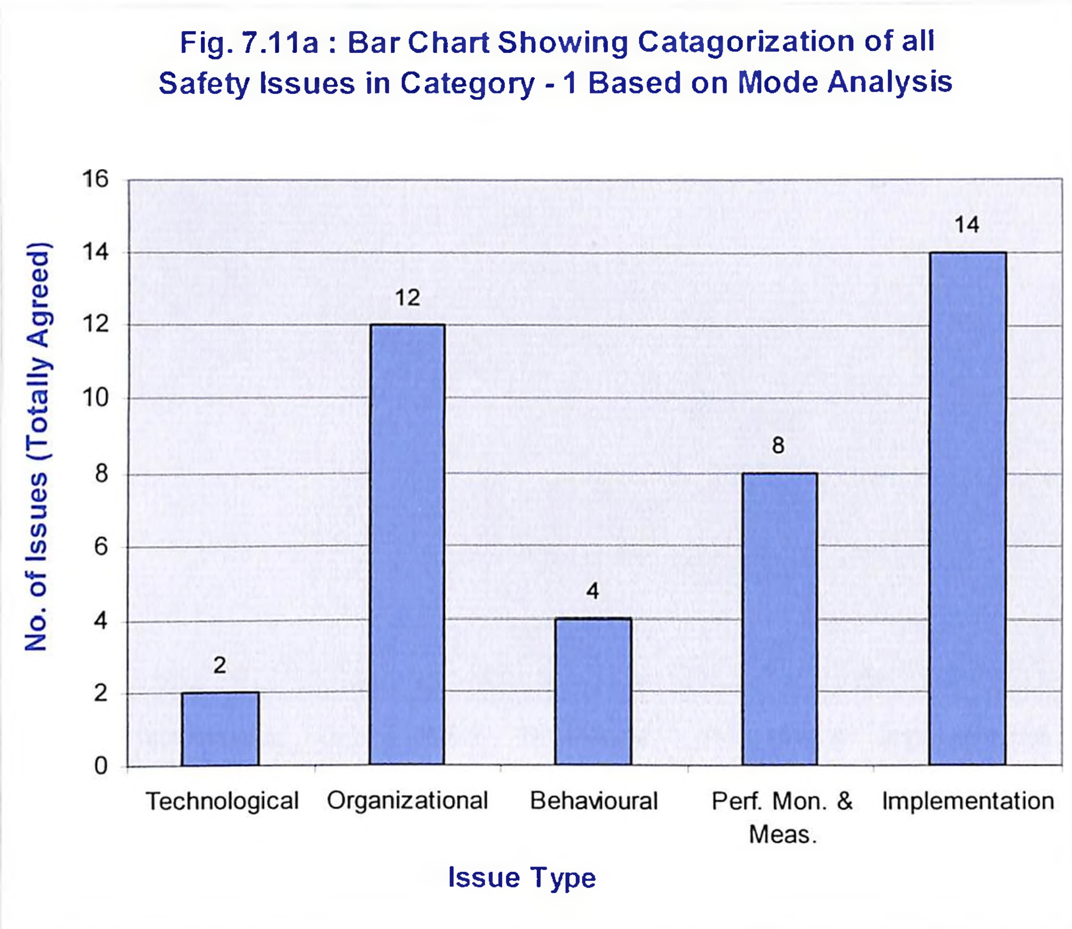


Fig. 7.11a : Bar Chart Showing Catagorization of all Safety Issues in Category - 1 Based on Mode Analysis
No. of Issues (Totally Agreed)
16
14
12
10
8
6
4
2
0
2
12
4
8
14
Technological
Organizational
Behavioural
Perf. Mon. & Meas.
Implementation
Issue Type

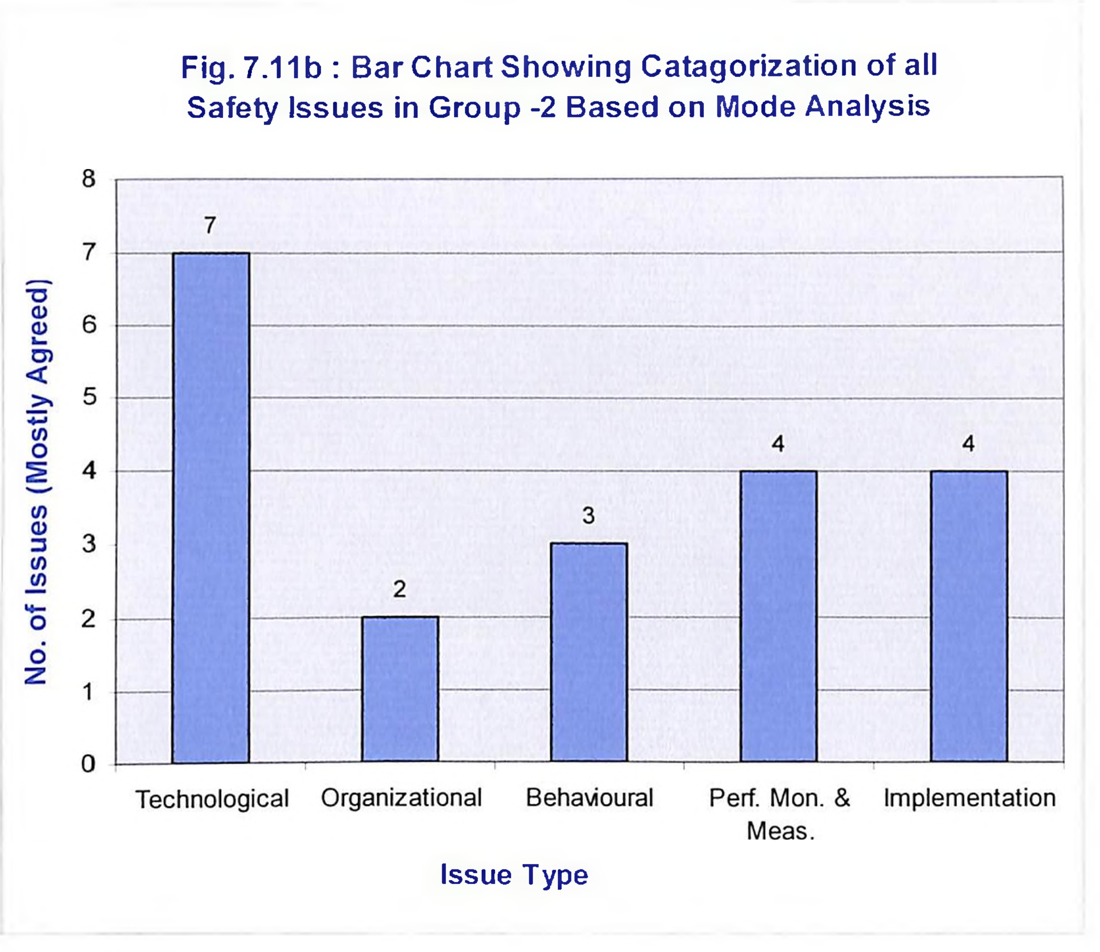


Fig. 7.11b : Bar Chart Showing Catagorization of all Safety Issues in Group -2 Based on Mode Analysis
No. of Issues (Mostly Agreed)
8
7
6
5
4
3
2
1
0
7
2
3
4
4
Technological
Organizational
Behavioural
Perf. Mon. & Meas.
Implementation
Issue Type

Fig. 7.11c : Bar Chart Showing Catagorization of all Safety Issues in Group - 3 Based on Mode Analysis

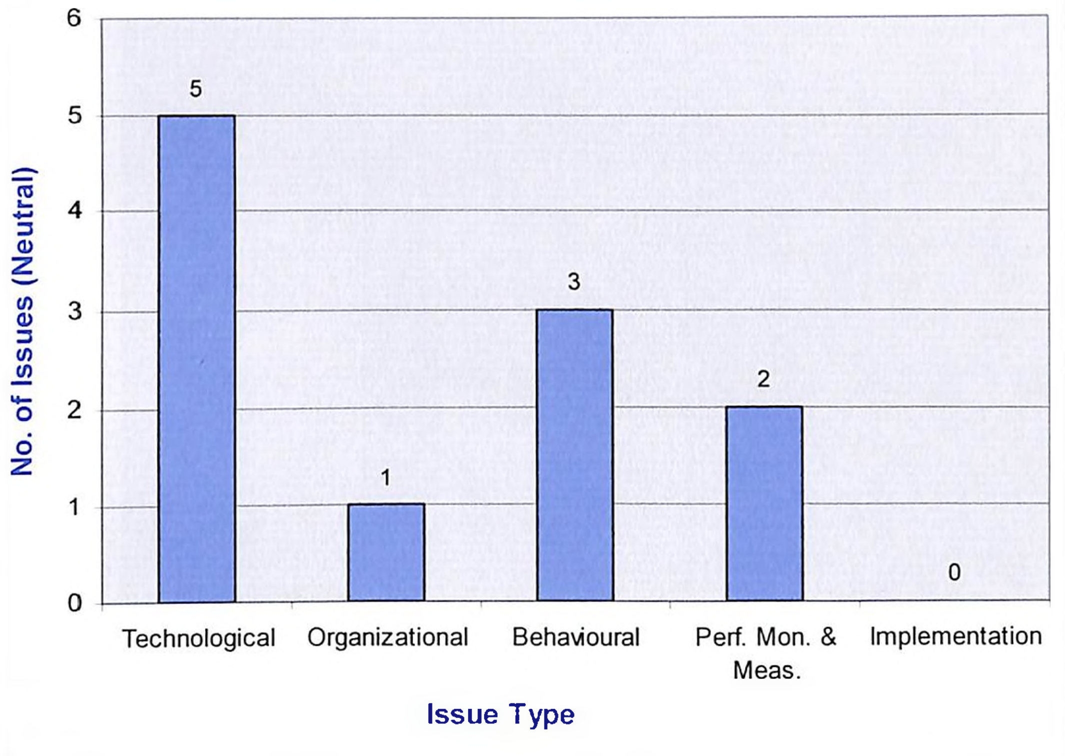
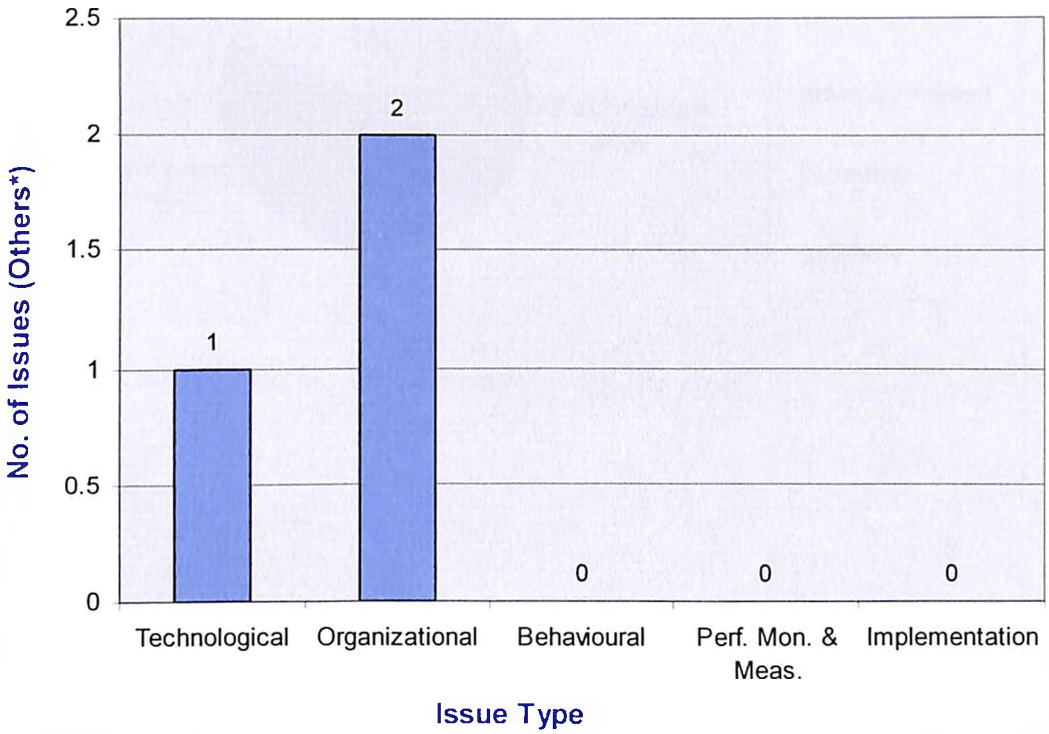
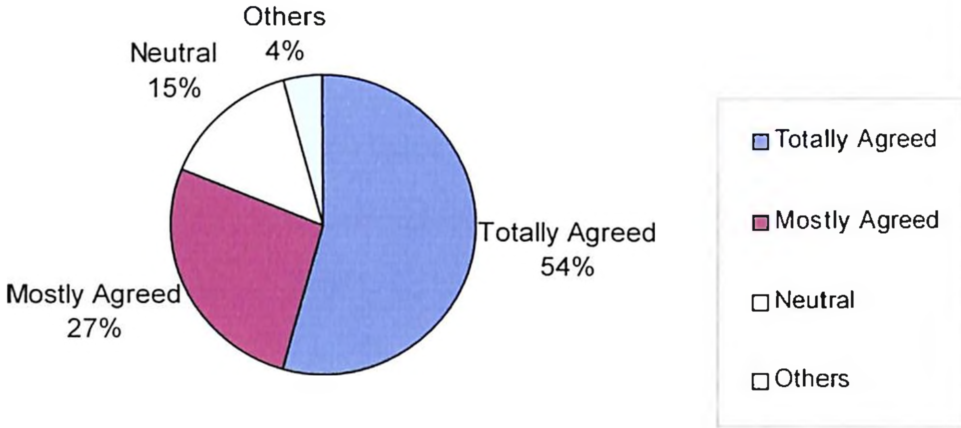


Fig. 7.11d : Bar Chart Showing Catagorization of all Safety Issues in the others* catagory Based on Mode Analysis



* Includes totally Disagree & Tend to Agree

Fig. 7.11e : Pie Chart Showing Portion of Safety Issues Catagorized in Groups 1, 2 & 3



The mode analysis also reveals that question no. 13 (small & medium contractors are capable of achieving safety goals & objectives) and questions no. 14 (sub-contractors under small & medium category depute qualified safety personnel at the work site) are responded as "totally disagree". This response is considered as quite correct as can generally be seen from majority of the work sites where the prime contractor/ client deploys safety personnel rather than the small / medium subcontractor. Similarly Q. No. 9 (Most of the accidents injuries occur at project sites are due to defective tools and equipments) is responded as 'tend to agree'.

7.4.2 Correlation Analysis

The study further established significant correlation of various issues (Q. Nos. indicated in Table - 7.2 corresponds to those in Anneure-1) with the three criteria for safety performance measurement as follows:

(i) Frequency Rate of Lost Time Accident (FRLTA) was found to have negative correlation with the following issues:

- Carrying out specialized activities under supervision of trained and qualified person (p=0.01),
- Poor housekeeping (p=0.05)
- A systems approach with clear roles & responsibilities (p=0.05)
- Workers awareness of occupational hazards (p=0.05)
- Measurement of safety performance (severity and frequency rate) based on lost time accident data (p=0.01)
- Positive promotion of safety culture through essay competition on safety issues (p=0.01)
- Rewarding employees and contractors for achieving safety goals (p=0.01).
- Safety task assignment before start of a new job or start of a shift (p=0.01).
- To establish safety goals & objectives for every project (p=0.05).
- Safety kick- off meetings prior to start of every project (p=0.01).

- Approve, health, safety & environment plans for contractor / subcontractor (p=0.05).
- Decide policy & practices for safety audits, inspection, accident/ near-miss investigation & reporting policies (p=0.01)
- Insist for pre-task planning. Hazard identification & Job safety analysis (p=0.01)
- Continuous monitoring of workers behaviour to prevent unsafe acts (p=0.01)
- Post completion safety report highlighting reward of achievers (p=0.01)

The negative correlation is also in agreement with practical experience with regard to accident prevention since with increased management support and safety initiative accident rate is generally found to decline.

(ii) Frequency Rate of Recordable Incidences (FRRI) is observed to have negative correlation with the various issues as noted below:

- Ensure availability of MSDS of various chemicals being used at site (p=0.05)
- Indulging in unsafe act by proceeding with a job totally ignoring the associated hazards (p=0.01).
- Measurement of safety performance based on frequency & severity rate of fatality (p=0.05).
- Establish safety goals & objectives for every project (p=0.05).

- Decide policy & practices for safety audits, inspection, accident/ near-miss investigation & reporting policies (p=0.01)
- Develop procedure for work permit to control unsafe conditions (p=0.01).
- Post completion safety report highlighting reward of achievers (p=0.05)

(iii) Severity Rate of Lost time Accident (SRLTA) is found to have correlation with the following issues:

- Routine inspection of lifting tools and tackles (p=0.05).
- Capability of small & medium sub-contractors to meet the technological and legislation requirements (p=0.05)
- Deployment of qualified safety personnel by small & medium sub-contractors (p=0.01).
- Workers awareness of safety hazards (p=0.01).
- Top management's commitment & support (p=0.01).
- Workers hesitation to carry on with the job in the face of detection of any unsafe conditions (p=0.01).
- Prior selection of trained & qualified safety professional (p=0.01).
- Develop safety training and orientation programme (p=0.05).

7.4.3 Regression Analysis

The study also suggests a linear regression Model of SRLTA with the various issues as depicted above in para 7.3 after the Table-7.8. The R^2 value of 0.945 suggests a strong fit of the variables (issues) with the outcome performance, Severity Rate of lost Time Accidents (SRLTA). Referring to the above model it is observed that there are seven issues associated with the Model as explained in Table 7.12 below.

Table - 7.12 : Description of Issues in the SRLTA Model and their Classification

Sl. No.	Issue (Q.No.)	Issue Description	Type of issue
1	02.	Imported machinery provides better safety.	Technological
2	18	Selection of subcontractors based on their past performance regarding safety.	Organizational
3	23(viii)	Lack of knowledge of Supervisors/Managers regarding safety legislation.	Organizational
4	30(i)	Measurement of safety performance based on frequency rate and severity rate of Lost time Accident.	Performance Monitoring and Measurement.
5	30(iii)	Measurement of safety performance based on frequency rate and severity rate of Record able Incidences.	Performance Monitoring and Measurement
6	32(iv)	Positive promotion of safety through reward of employees and contractors	Performance Monitoring and Measurement
7	36(iv)	Post completion Project safety report to highlight rewarding of achievers.	Implementation

From Table – 7.12 it may be observed that Severity rate of LTA is influenced by the seven issues of the following types:

- Technological
- Organizational

- Performance Monitoring
  And Measurement
- Implementation

Having identified the issues it is necessary to adopt a process approach for controlling the same for achieving better safety performance. A systematic approach requires control measures of the following three types:

- Engineering
- Education and
- Enforcement

The following Table 7.13 describes the systematic actions suggested for control of the issues identified (Ref. Table 7.12) so that a process for continual improvement is set in which in turn will lead to safety excellence.

Table : 7.13 : Safety Assurance Model based on SRLTA

SL. NO.	SRLTA Control Items.	CONTROL MEASURES			Effectiveness of Control	Review & Plan for Implementation.
		Engineering	Education	Enforcement		
01	Use of Imported Machinery / Equipment for better safety.	Ensure availability of Manufacturers catalogue / Operations Manual.	Conduct Training & Awareness programme for concerned workers, (OHSAS : 18001 Cl. No. 4.42)	(i) Verification of Purchased Machinery / Eqpt. (ISO : 9001 : 2000 Cl. No. 7.4.3) (ii) Periodic Inspection as per Project Safety Manual / Work practices (OHSAS – 18001, Cl. No. 4.5.1)	Safety Audit (OHSAS 18001 : Cl. No. 4.5.4)	(i) Management Review, (OHSAS – 18001 : Cl. No. 4.6) (ii) Corrective & Preventive Action (OSHAS 18001 : Cl. No. 4.5.2)
02	Selection of Sub Contractors based on their past performance of Safety.	Documented Procedure for Selection of Suppliers as per ISO 9001 : 2000, Cl. No. 7.4.1	Ensure awareness of operating Procedures, Quality Manual, for the Procurement Staff.	Approval of Sub Contractors bid & issue of Purchase / Service order only on compliance to applicable operating procedures.	Quality Audit (ISO 9001 : 2000, Cl. No 8.2.2)	Management Review. (ISO 9001 : 2000, Cl. No. 5.6 & OSHAS 18001, Cl. No… 4.6) followed by Corrective & Preventive Actions as appropriate.
03	Lack of knowledge of Managers / Supervisors on Safety Legislation.	(i) Prepare list of safety legislation as applicable for the Project. (ii) Incorporate the legislative requirements in the Safety Manual and Operating Procedure.	Conduct Safety Orientation & Training for Managers & Supervisors before deploying them to Project. (OHSAS 18001, Cl. No. 4.4.2)	Safety Walk down by Top Management & Site Safety managers for better implementation.	Safety Audit (OSHAS 18001 : Cl. No. 4.5.4)	Management Review (OHSAS 18001 : Cl. No. 4.6) Corrective & Preventative Action. (OHSAS – 18001 Cl. No. 4.5.2)

SL. NO.	SRLTA Control Items.	CONTROL MEASURES			Effectiveness of Control	Review & Plan for Implementation.
		Engineering	Education	Enforcement		
04	Measurement of Safety Performance based on ' Frequency rate ' & 'Severity rate' of Lost time accidents.	Safety Performance Measurement criteria to include FRLTA & SRLTA and be a part of Safety Manual.	Ensure Workers awareness of Safety Manual and Work Procedure. (OHSAS 18001, Cl. No. 4.4.2)	To track safety performance data on a periodic basis for every project and be a part of Management Reporting System. (OHSAS 18001, Cl. No. 4.5.1)	Review performance data on a periodic basis as per Safety Manual. (OHSAS 18001, Cl.No. 4.5.1)	Management Review (OHSAS 18001 Cl. No. 4.6) to ensure compliance to set goals.
05	Measurement of safety Performance based on Frequency Rate & Severity Rate of Total Incidence.	Safety Performance Measurement criteria to include Frequency Rate & Severity Rate of total incidence.	- Do -	- Do -	- Do -	- Do -
06	Positive Promotion of Safety through reward of employees & contractors for realization of set goals.	Safety Manual to include Safety promotion measures containing reward for achievement of goals.	- Do -	Safety Promotion Measures should be visible, e.g celebrations of milestones achievement with participation of all Employees & Contractor.	Periodic Safety observation to scrutinized behavior of people at work with regard to safety practices.	Management Review (OHSAS 18001 : Cl. No. 4.6)
07	Generation of Safety statistics to facilitate further research.	Maintenance of Record to include Safety Statistics and shall be included in the Safety Manual. (OHSAS 18001, Cl. No. 4.5.3)	- Do -	Performance Record shall be reviewed by top Management on a periodic basis. (OHSAS 18001, Cl. No. 18001, 4.6)	Safety Audit (OHSAS 18001, Cl. No. 4.5.4)	- Do -

CHAPTER – 8

CONCLUSION

8.0 Introduction

Construction is recognized as a hazardous industry. Accidents in construction affects the bottom line of an organization by way of loss of lives of people, damage to equipment / properties and also disrupts the process. In the light of above, the study of achieving excellence in construction safety has been amply justified as the need of the hour.

Lack of safety performance data and research in the area of construction safety has been identified as impediments for determining the level of safety excellence of Indian Construction Industry.

Based on literature review, review of current status and study of important models a set of issues affecting safety performance has been prepared. For better understanding of the problem and identification of the issues affecting safety performance, the issues have been grouped into five categories viz.; (i)Technological, (ii) Organizational (iii) Behavioural (iv) Performance Monitoring & Measurement and (v) Implementation.

From the study of the three important models it has also been observed that none of these models have been successful in establishing a relationship of the input variables (issues) with safety performance (outcome) measure.

Further, there is no empirical model for assessing the safety performance measures, which can be quantified and used for benchmarking purposes. The present research looks into these deficiencies. The literature review has also revealed the fact that there has not been any previous research in the area of Construction Safety in India. Works of various authors (Vaid, 2000, Smith 1999) is found to have corroborated this observation.

Frequency rate of lost time accidents, frequency rate of recordable incidence and severity rate of lost time accidents have been found to be mostly in use for tracking the safety performance of construction industry.

The study & analysis of technological issues, organizational issues, behavioural issues performance monitoring & measurements issues has resulted in identification of the specific issues of these categories which has significant relationships with the above noted safety performance issues.

The use of mode analysis has helped in determining the issues, which are crucial for imp [acting the safety performance based on the perception of the respondents.

The correlation analysis has resulted in identification of the various issues having significant correlation ($p = 0.01$ & $p = 0.05$) with the safety performance criteria, viz. "FRLTA, FRRI, SRLTA"

The study of results of Regression Analysis has helped in determining the linear regression relationship of the dependant variable (the safety performance criteria, i.e. FRLTA, FRRI, SRLTA) with the independent variables (safety issues). The goodness of the suggested regression model has also been determined with the value of R^2 "t" statistics and "significance" value as obtained in the regression analysis.

The survey response data were analyzed category wise i.e. technological, organizational, behavioural, performance monitoring & measurement and implementation. The analysis has identified the significant issues belonging to these categories, which impacts the safety performance.

Similar analysis has been done with all the issues together and the results have identified the various significant issues as a combined effect of all the issues .The study has also determined Regression Modes for SRLTA of all the above category of issues considered separately 7 also jointly.

8.1 Technological Issues

The mode analysis has helped in identifying the following four technological issues, which have been found to be "totally agreed" by the respondents to impact construction safety performance

(i) Carrying out specialized construction activities (excavations, trenching, etc.) under supervision of trained & qualified supervisor.

(ii) Control of hazards of damaged insulation of cables

(iii) Inadequate earthing of electrical equipment, and

(iv) Use of material handling equipment with proper certification.

From the results of the correlation analysis, it has been established that two of the above four technological issues, viz. Carrying out specialized construction activities (excavations, trenching, etc.) under supervision of trained & qualified supervisor and Use of material handling equipment with proper certification has been found to be significantly correlated ($p = 0.05$) with Frequency Rate of Lost Time Accidents(FRLTA) (Table 5.3). These are also found to have negative correlations ($p = 0.05$). This lead us to believe the correctness of the hypothesis that more the job is under supervision the less will be the chance of Frequency Rate of Lost Time Accidents (FRLTA).

The correlation analysis has also identified the following two technological issues are significantly correlated to Frequency Rate of recordable Incidence (FRRI).

a) Hazards from use of Construction Machinery ($p = 0.05$), and

b) Availability of Material Safety Data sheet (MSDS) of construction chemicals help in prevention of safety hazards ($p = 0.01$)

The negative correlation for MSDS justifies the practical observation at site that more the MSDS for chemicals are made available; the more will be the awareness of the people, which in turn may cause less number of accidents.

The following five technological issues have been identified to have significant correlation with the Severity Rate of Lost Time Accidents (SRLTA):

(i) Indigenously developed plants and equipments are not designed to include operator's health and safety. ($p = 0.05$)

(ii) Manufacturers of indigenous plants & equipments do not provide safety manuals to their buyers ($p = 0.01$)

(iii) Imported machinery provides better safety than locally developed equipments ($p = 0.05$).

(iv) Control of hazards through proper certification of material handling equipments ($p = 0.01$)

(v) Poor house –keeping ($p = 0.01$)

The outcome of the correlation analysis has identified the important and significant technological issues essential for prevention of accidents at construction sites. Management is required to address these issues as a matter of strategy and implement the preventive measures accordingly.

Lastly, it has been identified from Regression Analysis that SRLTA has a good regression fit with the technological issues since the value of R^2 for SRLTA has been found to be 0.941(R^2 value above 0.75, preferably 0.8 or more) is considered as good enough to establish a model. A suggested model of Regression –fit between SRLTA and Technological issues has been presented (Para 5.1.3.3).

8.2 Organizational Issues:

From the review of results of mode analysis and correlation analysis (Table 5.7 & Table 5.8), the following three organizational issues have been identified as significant with respect to FRLTA:

(i) The small & medium sub-contractors, who are not capable of meeting legislative and technological requirements of organizational safety ($p = 0.01$)

The positive correlations with the FRLTA is justified from the fact that the more the subcontractors are appointed with inadequate capability the more will be the FRLTA.

(ii) Sub-contractors deputing qualified safety professional at site ($p = 0.01$).

(iii) Deficient enforcement of safety ($p = 0.01$)

It has been found from the correlation analysis that organizational issues don't have significant correlations with FRRI (Frequency Rate of Recordable Incidents).

The correlation analysis has also identified that the following organizational issues are significantly correlated with SRLTA:

(i) Sub-contractor capability to meet legislative & technological requirements of safety ($p = 0.01$)

This issue was also found to impact the FRLTA. Accordingly, this has been considered as an important issue for control action.

(ii) Deployment of qualified safety personnel by sub-contractor ($p = 0.01$)

This issue is also common with FRLTA and therefore assumes priority for control action.

(iii) Other significant issues identified are

a) Participation of client representatives in the site safety team ($p = 0.01$)

b) Selection of sub-contractors based on there past performance on safety ($p = 0.05$)

c) Most of the accidents occur during the normal working hours ($p = 0.01$)

d) A systematic approach ($p = 0.05$) is essential for achieving zero accidents safety excellence.

e) Lack of proper training ($p = 0.01$)

f) Problems of wages & job security of workers ($p = 0.01$)

The correlation analysis findings have identified nine out of seventeen organizational issues which are quite significant in affecting the safety performance criteria (FRLTA & SRLTA). The outcome of correlation with FRRI may give better results with more numbers of cases having input on safety performance (FRRI).

Regression Analysis has evolved an empirical model of Severity Rate of Lost Time Accidents with R2 value of 0.945 Table 5 of Annexure – 3

8.3: Behavioural Issues:

The study of results of mode and correlation analysis has identified seven behavioural issues (out of 10 considered in the present research) as having significant correlation with the various safety performance criteria noted below:

a) Three issues of correlation with FRLTA (Table 5.13) are:

(i) Project/safety managers consider safety as a primary responsibility and demonstrates the same through their behaviour ($p = 0.05$)

(ii) Workers hesitate to carry on with the work in case any unsafe condition is detected ($p = 0.01$)

(iii) Workers proceed with the job in spite of detection of an unsafe condition ($p = 0.01$)

The positive correlation of point (i) above is in conformance to our physical observation in construction sites. It is expected that with increasing number of managers owning safety responsibility, the frequency of lost time accidents should be reduced.

Similarly, the positive correlations for point (iii) above are also in line with the real life situation at site. it may be observed, that the more the workers carry on with the jobs in spite of detection of unsafe condition at site, the more is likely to be the FRLTA.

b) FRRI is found to have correlation with the only organizational issue " Workers proceed with the job totally ignoring the hazard".

c) Following three organizational issues are found to have significant correlation with SRLTA:

   (i) Workers hesitate to carry on with the job in case any unsafe condition is detected (p = 0.01)

   The negative correlation shows that the more the hesitation of workers to work in an unsafe condition, the less will be the SRLTA, which is an expected phenomenon. This issue is also identified in the results of the correlations with FRLTA. Thus the issue is considered very important from the controlling point of view.

   (ii) Worker's failure to identify the unsafe conditions (which occurred prior to start of work or developed during the work) leads to accidents (p = 0.01) A positive correlation signifies the fact that more the failure is detected of an unsafe condition, the more is likely to be the SRLTA. This requires specific training of workers on "Hazard identification & Control".

   (iii) Lack of awareness of passive hazards leading to unsafe acts (p = .01). As explained in (ii) above, the positive correlations for lack of awareness with SRLTA is in line with practical phenomenon.

The remedial measure for both the issues at (ii) & (iii) are the same. Regression Analysis with SRLTA suggests an empirical model of SRLTA with the behavioral issues, (with R^2 = 0.942, Table 5 of Annexure - 3 developed from the regression coefficients shown in Table 5.14 It may be noted that no empirical model could be derived from FRLTA & FRRI from Regression Analysis due to small values of R^2 (0.406 for FRLTA & 0.559 for FRRI). The results may be further improved with more number of cases made available for the analysis.

8.4: Performance Monitoring & Measurement Issues:

The results of mode analysis have shown that out of 14 issues under performance monitoring & measurement (Annexure-1D), 12 issues are "totally agreed" by the respondents as significant for accident prevention and the remaining two issues are "mostly agreed". No issue has been responded as (Neutral/Tend to agree/Disagree).

Review of results of mode analysis and correlation analysis revealed the following significant issues:

a) Frequency Rate of Lost Time Analysis (FRLTA): the following five issues have been found to be negatively correlated with FRLTA.

   (i) Measurement of safety performance based on Frequency rate & Severity rate of lost time accidents (p =0.01)

   (ii) Positive promotion of safety through poster/banner/competition (p =0.05)

(iii) Positive promotion of safety through "Essay competition on safety issues" (p = 0.05)

(iv) Rewarding employees for achievement of goals (p = 0.01)

(v) Safety task assignment before start of every shift & any new job. (p= 0.01)

b) Frequency Rate of Recordable Accidents (FRRI): The only performance monitoring issue found to have significant correlation with FRRI is:

(i) Measurement of Safety Performance based on FRRI (p = 0.05)

c) Severity Rate of Lost Time Accidents (SRLTA): Six issues have been identified as significantly correlated to SRLTA as indicated below:

(i) Measurement of safety performance based on Frequency Rate & Severity Rate of Lost Time Accidents (p = 0.05)

(ii) Measurement of Safety Performance based on Frequency rate & Severity Rate of ' fatality' (p = 0.01)

(iii) Safety Walk down (a process of observation of construction activities across various locations in a construction site to identify any unsafe act/ unsafe condition) by top management (p = 0.05)

(iv) Positive promotion of safety through essay competition on safety issues. (p = 0.01)

(v) Rewarding of employee s for achievement of goals (p =0.05)

(vi) Safety task assignment before start of every shift & also new jobs (p=0.05)

Of the six issues identified above, 4 issues i.e. Sl. No.s (i), (iv), (v) & (vi) are also identified as having correlations with FRLTA and issue no. (ii) is also identified as having correlations with FRRI.Thus all these issues are found to be very important from the point of view of accident prevention.

Regression analysis results recommend an empirical model of regression fit between Performance Monitoring issues with SRLTA (R^2 = 0.939) indicated in Table 5 of Annexure -3.

However, no such regression model could be recommended for FRLTA and FRRI with R^2 values of 0.406 and 0.559 respectively. A better result may be obtained if more number of completed responses including safety performance data is available. Industry members' voluntary participation in this regard will be a matter of great achievement.

8.5 Implementation Issues

The results of mode analysis has revealed that of the 18 implementation issues considered 12 are totally agreed by the respondents and remaining 6 are mostly agreed. Thus all the issues are positively accepted by the respondents as most important for accident prevention.

Correlation Analysis has identified that 9 of the implementation issues are having significant correlation with the various performance criteria as noted below (Table 6.7):

(i) Pre-set goals and objectives for every project. This is common for all three criteria with level of confidence (p=0.05).

(ii) Prior selection of trained and qualified safety professional correlated to both FRLTA and SRLTA (p=0.01) in both the cases).

(iii) Safety training and orientation programme (p=0.05 in both FRLTA and SRLTA).

(iv) Decide Policy & Practice for safety audit, inspection & investigation and reporting of accidents / near-misses (p=0.01 for FRRI). This issue does not have significant correlation with FRLTA & SRLTA.

(v) Insist for pre-task planning, job safety analysis and hazard identification (p=0.01 for both FRLTA and SRLTA).

(vi) Procedure for work permit (p=01 for FRRI). This issue does not have any significant correlation with FRRI.

(vii) Disciplinary action for recurrent unsafe acts (p=0.01 for both FRLTA and SRLTA. No significant correlation with FRRI has been observed.

(viii) Post completion project safety report highlighting reward of achievers (common for FRLTA, FRRI & SRLTA.

Regression analysis results have determined an empirical regression model of SRLTA with the implementation issues with R^2 value of 0.966 (Table 6.11).

Results of Regression analysis, however, did not lead us to determine an empirical model for FRLTA and (R^2 =0.432 and 0.593 respectively).

8.6 Impact of Safety Issues

Having identified the significant issues belonging to five different categories i.e., technological, organizational, behavioural, performance monitoring and measurement and also implementation issues independently the overall impacts of all the issues have been determined. The major outcome of the combined analysis of all the issues are highlighted in the following paragraphs.

The Response Mode analysis has identified that of the 74 issues (total of all the 5 categories of issues) studied 40 have been totally agreed, 20 mostly agreed and 11 were neutral as per the response mode (Table 7.11). Of the remaining three, two issues viz., Small & Medium Contractors deploy qualified safety personnel at site and small & medium contractors are capable to achieve safety goals & objectives have been totally disagreed. The remaining one, i.e., most of the accidents occur during normal working hours has been observed as 'tend to agree'.

The study has identified significant correlation of different issues with FRLTA, FRRI & SRLTA as detailed in 7.4.2.

The Regression analysis results have indicated a very strong regression fit (R^2 = 0.945) of SRLTA with the various issues. The SRLTA model recommended in paragraph 7.3 containing 7 issues from the various categories as indicated below (Table 7.12).

- **Technological – 1 No.**
  - (i) Use of imported machinery for better safety.
- **Organization – 2 Nos.**
  - (i) Selection of sub-contractors based on their past performance.
  - (ii) Lack of knowledge of Supervisors/ Managers.

- **<u>Performance Monitoring & Measurement – 3 Nos.</u>**

  (i) Measurement of Safety Performance based on Frequency Rate And Severity Rate of lost time accident.

  (ii) Measurement of safety performance based on Frequency Rate & Severity Rate of Recordable Incidences.

  (iii) Positive promotion of safety through reward of employees and contractors.

- **<u>Implementation Issues – 1 No.</u>**

  (i) Post completion safety record to highlight rewarding of achievers.

For achieving safety excellence the significant issues identified need proper monitoring & control for the purpose of continual improvement. Therefore, a system approach has been recommended for this purpose. Considering the prevailing scenario in the Indian Construction Industry it has been decided to use a system model applying the basic requirements of OHSAS – 18001:1999 (The Occupation Health and Safety Assessment Series Standard) and ISO-9001:2000 (Quality Management System Requirements). The Recommended Systems approach for controlling the identified issues impacting Severity Rate of LTA is appended in Fig. 7.13.

Regression analysis has also been done in respect of FRLTA and FRRI. The R^2 value obtained were 0.334 and .264 respectively. Therefore, no regression model could be recommended for FRLTA & FRRI. The regression model was not suggested for FRLTA and FRRI when the various issues were tackled in separate groups (technical, organizational, etc.) also.

This may be due to one or more of the following problems associated with gathering of safety performances: (i) Construction Industry need demonstrated openness in sharing such performance related data. (ii) Statutory authorities also need implementation of reporting of data/ information on accidents as required by Building and Other Construction Workers Regulation (Regulation of Employment and conditions of services) Act, 1996.

With increased response in respect of complete questionnaire more cases will be available for research and analysis. This may lead to improved model for FRLTA and FRRI as well as.

8.7 Specific Contributions to the Area of Safety Research

(i) Lack of research work in the construction safety area were considered as a major impediment to the safety improvement in construction. The present research has set a path forward for such research.

(ii) A set of significant issues under various categories, viz., technological, organizational, behavioural, performance monitoring and measurement and implementation issues have been identified. This will help in prevention of accidents at site which in turn will set forth the journey to safety excellence.

(iii) The study has recommended models of Severity Rate of Lost Time Accident (SRLTA) against the above-mentioned issues independently as well as all the issues in a combined manner.

(iv) A Safety Assurance Model has been developed based on the identified (significant) issues along with their control measures in a systematic manner using requirements of OHSAS-18001 and ISO-2001 Standards.

8.8 Scope for Future Work

During the course of this study some directions for future work became apparent. These include:

- Safety performance excellence in construction may be broadened further to examine for other proactive performance measures like top management support, creation of supporting culture for safety implementation, etc.
- The present study has been done in an environment where acute shortage of performance data, willingness to respond and industry participation including openness to discuss issues related to safety climate have been noticed.

  Future prospective researchers need creation of awareness regarding utility of such research amongst the industry leaders through a series of interactive sessions at various places in the country. This may be ventured with the help of CIDC, Builders Association of India and other organizations like National Safety Council, etc. With the increased awareness much more response with reliable safety performance data may be obtained. Analysis of such voluminous data with adequate safety performance response may lead to the improvement of the present model.

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ANNEXURES

ANNEXURE – 1

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Kindly furnish your feedback / opinion on the questionnaire attached to facilitate to carry out a research on "CONSTRUCTION SAFETY EXCELLENCE" and establish bench marked practices for Construction Safety. The response may kindly be sent to: *Mr. N. Banerjee, General Manager (Quality), Simon India Ltd., Devika Tower, 6 Nehru Place, New Delhi – 110 019, E-mail nikhilesh.banerjee@simonindia.com* at the earliest.

RESPONDENT's (INDIVIDUAL OR ORGANIZATION) PARTICULARS

1. Name :

2. Address :

3. Type of Construction Business associated with (Please tick as appropriate) :

   (a) Buildings. :
   (b) Infrastructure. :
   (Roads, Bridges, Ports etc.)
   (c) Structural Erection :
   (d) Refinery/Petrochemicals :
   (e) Others (Please specify) :

4. No. of Employees

   (a) Managerial :
   (b) Supervisory Staff :
   (c) Workmen (Skilled :
   (d) Workmen (Unskilled) :
   Total :

5. CIDC-ICRA Grading * :
   (If applicable)
6. Volume of Business (In INR / US) :
   (Average for the last 3 years)

7. Contact Person for queries on Safety :
   Name. :
   Designation. :
   Phone No. :
   E. mail ID. :
8. Details of National / International excellence awards achieved during the last five years for demonstrating excellence in construction safety :
   (a)
   (b)
   (c)
   (d)
   (e)

* *Applicable for Indian Construction Organizations*

ISSUES IN SAFETY IMPLEMENTATION: QUESTIONNAIRE

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

1 = Not at all important 2 = Somewhat important
3 = Important. 4 = Very Important 5 = Most important.

TECHNOLOGICAL ISSUES

(1)	Do you feel use of construction Machineries / Equipments (Mixing / Batching plants, Concrete Pumps, Shovels, Dumpers, Excavators, Welding equipments, DG sets etc.) possess safety hazards in your execution of work ?	1 | 2 | 3 | 4 | 5
(2)	Do the imported machineries / equipments provide better safety in their use than compared to domestic equipments ?	1 | 2 | 3 | 4 | 5
(3)	While importing such machinery do you always insists for training of your employees to ensure better safety & Productivity ?	1 | 2 | 3 | 4 | 5
(4)	Regarding use of various chemicals, paints, thinners, fuels, (Diesel, Petrol) and explosives do you ensure availability of Materials Safety Data Sheets (MSDS) to prevent any inadvertent misuse / improper handling and storage leading to safety hazards.	1 | 2 | 3 | 4 | 5
(5)	Indigenously developed plants and equipments, in general are not designed to include the Operators' health & safety and ease of handling aspects	1 | 2 | 3 | 4 | 5
(6)	Manufacturers of indigenously developed plants and equipment Safety Manuals do not supply to their Buyers.	1 | 2 | 3 | 4 | 5
(7)	Excepting a very few manufacturers, generally no other Manufacturer provides training to buyers personnel in the safe handling and routine periodic maintenance of the plants and equipments supplied.	1 | 2 | 3 | 4 | 5
(8)	Specialized activities involved in excavation, trenching, tunneling, erection of structures, if carried out by unskilled workers without proper supervision by a trained and qualified persons, pose a serious threat to safety?	1 | 2 | 3 | 4 | 5
(9)	Do you feel that most of the accidents / injuries occur to Project sites are due to defective tools and	1 | 2 | 3 | 4 | 5

equipments.

(10) Please indicate the significance of the following in the prevention of accidents/injuries (on a 1 to 5 point scale noted above)

(i)	Defective hand tools & power tools	1	2	3	4	5
(ii)	Routine inspection of lifting tools & tackles	1	2	3	4	5
(iii)	Damaged insulation of cables	1	2	3	4	5
(iv)	Inadequate earthing of electrical equipments	1	2	3	4	5
(v)	Mechanical handling equipments (Cranes/Hoists/ Lifting tackles) without proper certification	1	2	3	4	5
(vi)	Poor House Keeping	1	2	3	4	5

ORGANIZATIONAL ISSUES

(11) Do you have a coherent Project Safety Policy & Objectives and preset goals in all your project sites? : Yes Always/Sometime/ Never

(12) Do have a Project Safety Plan in place to meet the above Policy, objectives & goals? : Yes Always/Sometime/ Never

(13) In execution of a construction project the prime Contractor appoints a number of Small / Medium Sub contractors. Do you feel they are quite capable of meeting the legislative & technological requirements in achieving safety goals & objectives? YES | NO

(14) Do these sub contractors depute qualified safety Personnel for implementation of the Safety Programme? YES | NO

(15) Do you organize site safety team with representatives from all contractors & sub contractors? YES | NO

(16) In your site execution whether Client's representative is a member of the site safety team? YES | NO

(17) What is the planed expenditure (in terms of % of project turnover) in respect of providing

i) PPE (Personal Protective Equipment) [ ] equipments.

(10) Please indicate the significance of the following in the prevention of accidents/injuries (on a 1 to 5 point scale noted above)

(i)	Defective hand tools & power tools	1	2	3	4	5
(ii)	Routine inspection of lifting tools & tackles	1	2	3	4	5
(iii)	Damaged insulation of cables	1	2	3	4	5
(iv)	Inadequate earthing of electrical equipments	1	2	3	4	5
(v)	Mechanical handling equipments (Cranes/Hoists/ Lifting tackles) without proper certification	1	2	3	4	5
(vi)	Poor House Keeping	1	2	3	4	5

ORGANIZATIONAL ISSUES

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(14) Do these sub contractors depute qualified safety Personnel for implementation of the Safety Programme? YES | NO

(15) Do you organize site safety team with representatives from all contractors & sub contractors? YES | NO

(16) In your site execution whether Client's representative is a member of the site safety team? YES | NO

(17) What is the planed expenditure (in terms of % of project turnover) in respect of providing

i) PPE (Personal Protective Equipment) [ ]

ii) Training on your employees for effective implementation of safety programme. [ ]

(18) Do you select your sub contractors based on their past performance with regard to safety amongst other criteria like price, delivery etc? : Yes Always/Sometime/Never

Is this a mandatory requirement for you? : Yes always/ Sometimes/ Never

(19) How much percentage (on an average) of project turnover do you spend towards positive promotion of safety culture? [ ]

(20) Do you employ Cost of Quality approach in determining the effectiveness of your safety implementation programme?

YES	NO

(21) What is the share of your workers compensation as compared to project turnover (%) [ ]

(22) Do you agree that most of the accidents occur in Normal Working Hours rather than extended working hours (beyond the normal shift working)

YES	NO

(23) How significant are the following factors/statements in establishing a **Zero-Injury** Safety Excellence Programme in a Project Site
(Please specify observation on a 1 to 5 point Likert scale)

(i)	A systematic process approach having clear lines of roles and responsibilities accompanied by a 'two-way communication' mechanism for the identified hazards and risks related to the work sites.	1	2	3	4	5
(ii)	Lack of proper training	1	2	3	4	5
(iii)	Deficient enforcement of Safety	1	2	3	4	5
(iv)	Problems of wages and job security of workers	1	2	3	4	5
(v)	Workers awareness of occupational hazards	1	2	3	4	5
(vi)	Workers involvement in implementation documented Safety Procedures/Manual	1	2	3	4	5

(vii) Project Managers prioritization of schedule and cost over Safety and quality in some cases lead to job site Accidents/injuries

1	2	3	4	5

(viii) Lack of knowledge of Supervisors/Managers on Safety Legislation leading to exposure to continued unsafe conditions at construction sites

1	2	3	4	5

BEHAVIOURAL ISSUES.

(24) Organization's top management considers safety as a strategic issue and demonstrates active support by providing budgetary allocation and other resources (manpower, PPE, training, promotional expenditure etc) (Please respond on a 1 to 5)

1	2	3	4	5

(25) Do your Project / Construction Manager considers safety as a primary responsibility and exhibits behaviour in compliance to the project safety norms? : Yes always/Sometimes/Never

(26) Whether the employees / workers of contractors / subcontractors are provided with necessary PPE's and use them when at work. : Yes always/Sometimes/Never

(27) Whether the workers / employees hesitate to carry on with their work in case any unsafe situation (broken ladder, improper scaffolding, damaged tools etc,) is detected. ? : Yes always/Sometimes/Never

(28) Please give your response to the following statements:

(i) Construction accidents occur due to the failure of the worker to identify an unsafe condition that existed before the start of the job or developed during execution

1	2	3	4	5

(ii) Workers proceeding with the job even after identifying an unsafe condition but prior to its mitigation is a common phenomenon

1	2	3	4	5

(iii) Indulging into an unsafe act irrespective of the prevailing work environment

1	2	3	4	5

(29) Unsafe act by an worker is primarily due to:

(i)	Awareness about the possible hazards not available	1	2	3	4	5
(ii)	Delayed communication/miscommunication of the hazard(s) at work	1	2	3	4	5
(iii)	Proceeding with the job totally ignoring the hazards	1	2	3	4	5

PERFORMANCE MONITORING AND MEASUREMENT.

(30) Measurement of safety performance is based on (Please tick as appropriate) the "severity " and "frequency" rates related to:

(i)	Loss time accidents	1	2	3	4	5
(ii)	Fatality	1	2	3	4	5
(iii)	Total incidences	1	2	3	4	5

(iv) Any other criteria (please specify) :

(31) Continual monitoring of Safety Performance is best achieved by :

(i)	Daily Inspection of tools & tackles.	1	2	3	4	5
(ii)	Safety walk downs by Top Management.	1	2	3	4	5
(iii)	Root cause analysis of accidents and near misses.	1	2	3	4	5
(iv)	Watching behaviour of Workmen, Supervisors and Managers at work for compliance to safety practice.	1	2	3	4	5

(32) Positive promotion of safety culture by way of:

(i)	Poster / banner competition.	1	2	3	4	5
(ii)	Essay competition on safety issues.	1	2	3	4	5
(iii)	Celebration of achievement of significant milestone(s).	1	2	3	4	5

(iv) Rewarding employees and contractors for achieving set goals.

1	2	3	4	5

(v) Punitive action for habitual offenders of safety Practices.

1	2	3	4	5

(33) Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention.

1	2	3	4	5

(34) Inspection of Personal Protective Equipment for assessing their suitability for use is a must for reducing impact of accidents.

1	2	3	4	5

(35) Effective Implementation of Safety is achieved by the following practices (please indicate your rating, if these are being followed)

(i) To establish a preset Safety Goals and Objectives for every project.

1	2	3	4	5

(ii) Safety kick off meetings before start of the project.

1	2	3	4	5

(iii) Prior selection of trained and qualified Safety Professional

1	2	3	4	5

(iv) Develop Safety Training and Orientation Programme.

1	2	3	4	5

(v) Approve Health, Safety and Environment (HSE) Plan of Contractors / Sub-Contractors.

1	2	3	4	5

(vi) Decide Policy and Practices for Safety Audits, inspection, accident / near-miss investigation & reporting policies.

1	2	3	4	5

(vii) Establish procedures for emergency, medical and security response.

1	2	3	4	5

(viii) Establish Procedure for tracking of safety reports, Statistics for assessment of continual improvement.

1	2	3	4	5

(ix) Insists for Pre-task planning, Hazard Identification & Job Safety Analysis.

1	2	3	4	5

(x) Develop Procedure for work permits to ensure unsafe Conditions, if any are tackled effectively.

1	2	3	4	5

(xi) Project Safety Committee with the involvement of Clients, Contractors & Sub-Contractors representatives to achieve the common safety goals. | 1 | 2 | 3 | 4 | 5 |

(xii) Positive promotion of a good safety culture. | 1 | 2 | 3 | 4 | 5 |

(xiii) Continuous monitoring of workers' behaviour to Prevent unsafe acts through training, orientation, counseling, etc. | 1 | 2 | 3 | 4 | 5 |

(xiv) Disciplinary actions for stricter enforcement of recurrent unsafe acts. | 1 | 2 | 3 | 4 | 5 |

36 Post completion Safety Programme through a project safety report highlighting

(i) Significant achievements | 1 | 2 | 3 | 4 | 5 |

(ii) Lessons learn from the Project | 1 | 2 | 3 | 4 | 5 |

(iii) Reward the Achievers | 1 | 2 | 3 | 4 | 5 |

(iv) Generate statistics to help further research | 1 | 2 | 3 | 4 | 5 |

37 Summary of your Safety Accomplishment Record for the last 5 years -

	1998	1999	2000	2001	2002
(i) Frequency rate of accidents (loss time)					
(ii) Frequency rate of Recordable Incidences					
(iii) Severity rate of Lost Time Accident					
(iv) EMR - OSHA 200 Log (where applicable)					

Name :

Designation :

Organization :

Date **Signature (optional) :**

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

1 = Not at all important 2 = Somewhat important
3 = Neutral (Importan). 4 = Very Important 5 = Most important.

TECHNOLOGICAL ISSUES

(1)	Do you feel use of construction Machineries / Equipments (Mixing / Batching plants, Concrete Pumps, Shovels, Dumpers, Excavators, Welding equipments, DG sets etc.) possess safety hazards in your execution of work ?	1 | 2 | 3 | 4 | 5
(2)	Do the imported machineries / equipments provide better safety in their use than compared to domestic equipments ?	1 | 2 | 3 | 4 | 5
(3)	While importing such machinery do you always insists for training of your employees to ensure better safety & Productivity ?	1 | 2 | 3 | 4 | 5
(4)	Regarding use of various chemicals, paints, thinners, fuels, (Diesel, Petrol) and explosives do you ensure availability of Materials Safety Data Sheets (MSDS) to prevent any inadvertent misuse / improper handling and storage leading to safety hazards.	1 | 2 | 3 | 4 | 5
(5)	Indigenously developed plants and equipments, in general are not designed to include the Operators' health & safety and ease of handling aspects	1 | 2 | 3 | 4 | 5
(6)	Manufacturers of indigenously developed plants and equipment Safety Manuals do not supply to their Buyers.	1 | 2 | 3 | 4 | 5
(7)	Excepting a very few manufacturers, generally no other Manufacturer provides training to buyers personnel in the safe handling and routine periodic maintenance of the plants and equipments supplied.	1 | 2 | 3 | 4 | 5

(8) Specialized activities involved in excavation, trenching, tunneling, erection of structures, if carried out by unskilled workers without proper supervision by a trained and qualified persons, pose a serious threat to safety?

1	2	3	4	5

(9) Do you feel that most of the accidents / injuries occur to Project sites are due to defective tools and equipments.

1	2	3	4	5

(10) Please indicate the significance of the following in the prevention of accidents/injuries (on a 1 to 5 point scale noted above)

(i)	Defective hand tools & power tools	1	2	3	4	5
(ii)	Routine inspection of lifting tools & tackles	1	2	3	4	5
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(v)	Mechanical handling equipments (Cranes/Hoists/ Lifting tackles) without proper certification	1	2	3	4	5
(vi)	Poor House Keeping	1	2	3	4	5

(11) Summary of your Safety Accomplishment Record for the last 5 years -

		1998	**1999**	**2000**	**2001**	**2002**
(i)	Frequency rate of accidents (loss time)					
(ii)	Frequency rate of Recordable Incidences					
(iii)	Severity rate of Lost Time Accident					

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

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ORGANIZATIONAL ISSUES:

(1) Do you have a coherent Project Safety Policy & Objectives and preset goals in all your project sites? : | 1 | 2 | 3 | 4 | 5 |

(2) Do have a Project Safety Plan in place to meet the above Policy, objectives & goals? : | 1 | 2 | 3 | 4 | 5 |

(3) In execution of a construction project the prime Contractor appoints a number of Small / Medium Sub contractors. Do you feel they are quite capable of meeting the legislative & technological requirements in achieving safety goals & objectives? | 1 | 2 | 3 | 4 | 5 |

(4) Do these sub contractors depute qualified safety Personnel for implementation of the Safety Programme? | 1 | 2 | 3 | 4 | 5 |

(5) Do you organize site safety team with representatives from all contractors & sub contractors? | 1 | 2 | 3 | 4 | 5 |

(6) In your site execution whether Client's representative is a member of the site safety team? | 1 | 2 | 3 | 4 | 5 |

(7) Do you select your sub contractors based on their past performance with regard to safety amongst other criteria like price, delivery etc? : | 1 | 2 | 3 | 4 | 5 |

Is this a mandatory requirement for you? : | 1 | 2 | 3 | 4 | 5 |

(8) Do you employ Cost of Quality approach in determining the effectiveness of your safety implementation programme? | 1 | 2 | 3 | 4 | 5 |

(9) Do you agree that most of the accidents occur in Normal Working Hours rather than extended working hours (beyond the normal shift working)

1	2	3	4	5

(10) How significant are the following factors/statements in establishing a **Zero-Injury** Safety Excellence Programme in a Project Site
(Please specify observation on a 1 to 5 point Likert scale)

		1	2	3	4	5
(i)	A systematic process approach having clear lines of roles and responsibilities accompanied by a 'two-way communication' mechanism for the identified hazards and risks related to the work sites.	1	2	3	4	5
(ii)	Lack of proper training	1	2	3	4	5
(iii)	Deficient enforcement of Safety	1	2	3	4	5
(iv)	Problems of wages and job security of workers	1	2	3	4	5
(v)	Workers awareness of occupational hazards	1	2	3	4	5
(vi)	Workers involvement in implementation documented Safety Procedures/Manual	1	2	3	4	5
(vii)	Project Managers prioritization of schedule and cost over Safety and quality in some cases lead to job site Accidents/injuries	1	2	3	4	5
(viii)	Lack of knowledge of Supervisors/Managers on Safety Legislation leading to exposure to continued unsafe conditions at construction sites	1	2	3	4	5

(11) Summary of your Safety Accomplishment Record for the last 5 years -

	1998	**1999**	**2000**	**2001**	**2002**
(i) Frequency rate of accidents (loss time)					
(ii) Frequency rate of Recordable Incidences					
(iii) Severity rate of Lost Time Accident					

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

1 = Not at all important 2 = Somewhat important
3 = Important. 4 = Very Important 5 = Most important.

BEHAVIOURAL ISSUES.

(1) Organization's top management considers safety as a strategic issue and demonstrates active support by providing budgetary allocation and other resources (manpower, PPE, training, promotional expenditure etc) (Please respond on a 1 to 5)

1	2	3	4	5

(2) Do your Project / Construction Manager considers safety as a primary responsibility and exhibits behaviour in compliance to the project safety norms? :

1	2	3	4	5

(3) Whether the employees / workers of contractors / subcontractors are provided with necessary PPE's and use them when at work. :

1	2	3	4	5

(4) Whether the workers / employees hesitate to carry on with their work in case any unsafe situation (broken ladder, improper scaffolding, damaged tools etc,) is detected. ? :

1	2	3	4	5

(5) Please give your response to the following statements:

(i) Construction accidents occur due to the failure of the worker to identify an unsafe condition that existed before the start of the job or developed during execution

1	2	3	4	5

(ii) Workers proceeding with the job even after identifying an unsafe condition but prior to its mitigation is a common phenomenon

1	2	3	4	5

(iii) Indulging into an unsafe act irrespective of the prevailing work environment

1	2	3	4	5

(6) Unsafe act by an worker is primarily due to:

(i) Awareness about the possible hazards not available

1	2	3	4	5

(ii) Delayed communication/miscommunication of the hazard(s) at work

1	2	3	4	5

(iii) Proceeding with the job totally ignoring the hazards

1	2	3	4	5

(7) Summary of your Safety Accomplishment Record for the last 5 years -

	1998	1999	2000	2001	2002
(i) Frequency rate of accidents (loss time)					
(ii) Frequency rate of Recordable Incidences					
(iii) Severity rate of Lost Time Accident					

ANNEXURE – 1D

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

1 = Not at all important 2 = Somewhat important
3 = Important. 4 = Very Important 5 = Most important.

PERFORMANCE MONITORING AND MEASUREMENT ISSUES:

(1) Measurement of safety performance is based on (Please tick as appropriate) the "severity " and "frequency" rates related to:

(i)	Loss time accidents	1	2	3	4	5
(ii)	Fatality	1	2	3	4	5
(iii)	Total incidences	1	2	3	4	5

(2) Continual monitoring of Safety Performance is best achieved by :

(i)	Daily Inspection of tools & tackles.	1	2	3	4	5
(ii)	Safety walk downs by Top Management.	1	2	3	4	5
(iii)	Root cause analysis of accidents and near misses.	1	2	3	4	5
(iv)	Watching behaviour of Workmen, Supervisors and Managers at work for compliance to safety practice.	1	2	3	4	5

(3) Positive promotion of safety culture by way of:

(i)	Poster / banner competition.	1	2	3	4	5
(ii)	Essay competition on safety issues.	1	2	3	4	5
(iii)	Celebration of achievement of significant milestone(s)	1	2	3	4	5

(iv) Rewarding employees and contractors for achieving set goals.

1	2	3	4	5

(v) Punitive action for habitual offenders of safety practices.

1	2	3	4	5

(4) Safety Task Assignments before starting of the shift or starting of any new job helps in accident prevention.

1	2	3	4	5

(5) Inspection of Personal Protective Equipment for assessing their suitability for use is a must for reducing impact of accidents.

1	2	3	4	5

(6) Summary of your Safety Accomplishment Record for the last 5 years -

	1998	1999	2000	2001	2002
(i) Frequency rate of accidents (loss time)					
(ii) Frequency rate of Recordable Incidences					
(iii) Severity rate of Lost Time Accident					

QUESTIONNAIRE SURVEY ON IMPLEMENTATION OF SAFETY EXCELLENCE PROGRAMME

Based on your Experience, kindly indicate the importance of the following issues/statements on a 5 point (1-5) likert scale with the following ratings:

1 = Not at all important 2 = Somewhat important
3 = Important. 4 = Very Important 5 = Most important.

IMPLEMENTATION ISSUES:

(1) Effective Implementation of Safety is achieved by the following practices (please indicate your rating, if these are being followed)

(i)	To establish a preset Safety Goals and Objectives for every project.	1	2	3	4	5
(ii)	Safety kick off meetings before start of the project.	1	2	3	4	5
(iii)	Prior selection of trained and qualified Safety Professional.	1	2	3	4	5
(iv)	Develop Safety Training and Orientation Programme.	1	2	3	4	5
(v)	Approve Health, Safety and Environment (HSE) Plan of Contractors / Sub-Contractors.	1	2	3	4	5
(vi)	Decide Policy and Practices for Safety Audits, inspection, accident / near-miss investigation & reporting policies.	1	2	3	4	5
(vii)	Establish procedures for emergency, medical and security response.	1	2	3	4	5
(viii)	Establish Procedure for tracking of safety reports, Statistics for assessment of continual improvement.	1	2	3	4	5
(ix)	Insists for Pre-task planning, Hazard Identification & Job Safety Analysis.	1	2	3	4	5
(x)	Develop Procedure for work permits to ensure unsafe conditions, if any are tackled effectively.	1	2	3	4	5
(xi)	Project Safety Committee with the involvement of Clients, Contractors & Sub-Contractors representatives to achieve the common safety goals.	1	2	3	4	5

(xii) Positive promotion of a good safety culture.	1	2	3	4	5
(xiii) Continuous monitoring of workers' behaviour to Prevent unsafe acts through training, orientation, counseling, etc.	1	2	3	4	5
(xiv) Disciplinary actions for stricter enforcement of recurrent unsafe acts.	1	2	3	4	5

(2) Post completion Safety Programme through a project safety report highlighting

(i) Significant achievements	1	2	3	4	5
(ii) Lessons learn from the project	1	2	3	4	5
(iii) Reward the Achievers	1	2	3	4	5
(iv) Generate statistics to help further research	1	2	3	4	5

(3) Summary of your Safety Accomplishment Record for the last 5 years -

	1998	1999	2000	2001	2002
(i) Frequency rate of accidents (loss time)					
(ii) Frequency rate of Recordable Incidences					
(iii) Severity rate of Lost Time Accident					

ANNEXURE – 2

LIST OF PUBLICATIONS

1. Banerjee, N,; Deshpande, V.B. (2004); "Total Safety Management – A Cultural Approach to Accident Prevention"; NBCC – MDC Journal, Vol. 24-27, Oct. 2003 – July 2004; pp 18-24.
2. Banerjee, N.; Metri, B.A. and Deshpande, V.B., "Behaviour Based Safety: A Cultural Approach to Accident Prevention in Construction Industry'" – ACCEPTED for publication in National Productivity Council's Journal "PRODUCTIVITY" in their forthcoming Issue.
3. Banerjee, N.; Metri, B.A.; and Deshpande, V.B.; "Impact of Technological Issues in Construction Safety Performance".

   - UNDER REVIEW by the Editorial Board of Industrial Engineering Journal.
4. Banerjee, N.; Metri, B.A.; and Deshpande, V.B.; "Implementation Issues in Safety Excellence: A study of our Construction Industry".

   Under REVIEW by the Editorial Board of Civil Engineering & Construction Research (CE & CR) Journal.
5. Banerjee, N. & Deshpande, V.B.; "Construction Safety Regulations and Standards : An Overview'" – ACCEPTED for publication in "NBCC-MDC Journal" in forthcoming Issue.
6. Banerjee, N.; Metri, B.A.; and Deshpande, V.B.; "Construction Safety Performance Improvement through P – D – C – A Cycle"; Conf. Proc.; National Conf. On Tools

& Techniques of Quality & Productivity Improvement, Indian Statistical Institute, New Delhi, Feb, 8-9, 2005; pp : 115 – 120.

7. Banerjee, N.; Metri, B.A.; and Deshpande, V.B.; "Safety Excellence in construction – A study of Indian Scenario; " Conf. Proc. " Development of Physical Infrastructure – Synergic Approach; 8th convention on construction, Const. Ind. Dev. Council (CIDC), Oct, 20-22, 2005, Indian Habitat Center, New Delhi; pp : 181-199.

8. Banerjee,N.; "Safe Site Planning" ; conference proceedings; "National Seminar on Construction and Erection Risks" , Loss Prevention Association of India, India International Centre, New Delhi, June22-23,2000.

ANNEXURE-3

Table - 1 : Regression Model Summary of FRLTA with various issues

Model for Issue Type	R	R^2	Adjusted R^2	Std. Error of the Estimate
Technological	0.637	0.406	0.254	5.10930
Organizational	0.608	0.369	0.221	5.32632
Behavioural	0.637	0.406	0.254	5.10930
Performance Mon. & Meas.	0.637	0.406	0.254	5.10930
Implementation	0.637	0.432	0.286	4.86615

Table – 2 : Regression Model Summary of FRRI with various issues

Model for Issue Type	R	R^2	Adjusted R^2	Std. Error of the Estimate
Technological	0.866	0.750	0.670	1.88342
Organizational	0.512	0.262	0.098	2.52264
Behavioural	0.747	0.559	0.437	2.49181
Performance Mon. & Meas.	0.747	0.559	0.437	2.49181
Implementation	0.770	0.593	0.483	2.33695

Table – 3 : Regression Model Summary of SRLTA with various issues.

Model for Issue Type	R	R^2	Adjusted R^2	Std. Error of the Estimate
Technological	0.945	0.894	0.864	296.28598
Organizational	0.945	0.893	0.868	315.08147
Behavioural	0.940	0.883	0.850	319.03850
Performance Mon. & Meas.	0.942	0.887	0.851	317.61950
Implementation	0.942	0.887	0.851	317.61950

Table – 4 : Case wise Diagnostics of SRLTA with various Issues.

Model for Issue Type	Case NO.	Std. Residual	Value of Dependent variable	Predicted Value	Residual
Technological	1	4.251	2976.00	1716.6000	1259.4000
Organizational	1	3.997	2976.00	1716.6000	1259.4000
Behavioural	1	3.982	2976.00	1705.6787	1270.3213
Performance Mon. & Meas.	1	3.965	2976.00	1716.6000	1259.4000
Implementation	1	3.965	2976.00	1716.6000	1259.4000

Table – 5 : Revised Regression Model Summary of SRLTA with various issues (After Removal of Outliers)

Model for Issue Type	R	R^2	Adjusted R^2	Std. Error of the Estimate
Technological	0.970	0.941	0.923	202.37924
Organizational	0.972	0.945	0.932	205.44003
Behavioural	0.971	0.942	0.925	206.15648
Performance Mon. & Meas.	0.969	0.939	0.919	213.39446
Implementation	0.969	0.939	0.919	213.39446

BIO - DATA

1. Name : **NIKHILESH BANERJEE**

2. Date of birth : 5^{TH} April, 1951

3. Address : Flat No. B-37, Taksshila Aptt.,
57, I.P. Extension,
Delhi – 110 092
Tel: 011-42602307 (O)

4. Academic & Professional Qualification :
   i) B.E. (Mech.) 1972 from Bengal Engg. College, Shibpore (University of Calcutta) with first class (78%).
   ii) M. Tech (Mgmt. & Sys.) 1985 from Indian Institute of Technology, Delhi with 8.44 CGPA on a 10 point scale.
   iii) Certified Lead Auditor for QMS (ISO-9001), EMS (ISO-14001) & OHSAS 18001.

5. Professional & Academic Achievements :

   ii) More than 30 years experience in the field of Quality Management in reputed Public Sector Undertakings (GRSE, EPI & BHEL) and Private Sector Companies including Multinational Companies (Lurgi India, Fluor Daniel India). Presently working as General Manager (Quality) with Simon India Ltd.

   iii) Fellow of the Institution of Engineers (India).

   iv) Have experience in delivering experts lecture in the field of Construction Quality & Safety at IIT, Delhi, NICMAR and an adjunct faculty of CIDC.

   v) Was a member of a group of course writer for TQM for the M.B.A. Programme of IGNOU.

   vi) Member of the Jury for Fertilizer Productivity Award Committee of National Productivity Council.

   vii) Total 8 nos. of Research Papers published (including 2 nos. under review in reputed National Journal.

6. Research Interests:

   viii) Application of TQM in Product & Service Industries.

   ix) Safety initiatives in Refineries, Petrochemicals, Pipelines, etc.

   x) Project Management

Bio – DATA of Supervisor

1. Name : **Dr. V.B. DESHPANDE**

2. Date of birth : 9th September, 1939

3. Address : Prof. Emeritus,
   Dept. of Civil Engineering,
   IIT, Delhi, Hauz Khas,
   New Delhi – 110 016
   Tel: 011-26591185 (O)

4. Academic & Professional Qualification :

   i) B. Sc. (Engg.), Civil & Municipal, 1964 with 1st class from B.H.U. (Varanasi).

   ii) M.E. (Civil), 1968 with 1st Class Honours from University of Rourkee.

   iii) PhD 1979 from University of Liverpool, U.K.

5. Professional & Academic Achievements (with present designations):

   i) Distinguished Academician associated with Indian Institute of Technology, Delhi. Presently working as Professor - Emeritus, Deptt. of Civil Engineering.

   ii) Life Member of Indian Society of Technical Education (ISTE).

   iii) Guided more than 100 Thesis of M. Tech and PhD. Students of IIT, Delhi and other external candidates.

   iv) Research interest including Construction, Project Management, Value Engineering, Structural Engineering, Safety &Quality in Construction, etc.

   v) Published a good number of Papers in the National & International Journals.

   vi) Undertaken and completed more than 150 Industrial Consultancy Projects.