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Achieving Zero Accidents – A Strategic Framework for Continuous Safety Improvement in the Construction Industry

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ACHIEVING ZERO ACCIDENTS – A STRATEGIC FRAMEWORK FOR CONTINUOUS SAFETY IMPROVEMENT IN THE CONSTRUCTION INDUSTRY

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Rizwan Ul-Haque Farooqui

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DEDICATION

I dedicate this dissertation to my family, specifically my late father, my mother, my wife and my sister, without whose patience, understanding, support, and most of all love and sacrifice, the completion of this work would not have been possible.

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ABSTRACT OF THE DISSERTATION

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In the U.S., construction accidents remain a significant economic and social problem. Despite recent improvement, the Construction industry, generally, has lagged behind other industries in implementing safety as a total management process for achieving zero accidents and developing a high-performance safety culture. One aspect of this total approach to safety that has frustrated the construction industry the most has been "measurement", which involves identifying and quantifying the factors that critically influence safe work behaviors. The basic problem attributed is the difficulty in assessing what to measure and how to measure it – particularly the intangible aspects of safety. Without measurement, the notion of continuous improvement is hard to follow.

This research was undertaken to develop a strategic framework for the measurement and continuous improvement of total safety in order to achieve and sustain the goal of zero accidents, while improving the quality, productivity and the competitiveness of the construction industry as it moves forward. The research based itself on an integral model of total safety that allowed decomposition of safety into interior and exterior characteristics using a multiattribute analysis technique. Statistical relationships between total safety dimensions and safety performance (measured by safe work behavior) were revealed through a series of latent variables (factors) that describe the total safety environment of a construction organization. A structural equation model (SEM) was estimated for the latent variables to quantify relationships among them and between these total safety determinants and safety performance of a construction organization. The developed SEM constituted a strategic framework for identifying, measuring, and continuously improving safety as a total concern for achieving and sustaining the goal of zero accidents.

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LIST OF ACRONYMS

ACSNI	Advisory Committee on the Safety of Nuclear Installations
AGC	Associated General Contractors
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
A*v*	Average Variance
BBS	Behavior-Based Safety
BLS	Bureau of Labor Statistics
CEE	Civil and Environmental Engineering
CFA	Confirmatory Factor Analysis
CFR	Code of Federal Regulations
CII	Construction Industry Institute
CM	Construction Management
CRs	Critical Ratios
DV	Dependent Variable
EMR	Experience Modification Rating
ENR	Engineering News Record
FIU	Florida International University
GOF	Goodness of Fit
HSE	Health, Safety and Environment
IAEA	International Atomic Energy Agency
IMIS	Integrated Management Information System

INSAG	International Nuclear Safety Advisory Group
IOM	Institute of Medicine
IV	Independent Variable
LM	Lagrange Multiplier
LR	Likelihood Ratio
LWCIR	Lost Workday Case Incident Rate
MI	Modification Indices
NIOSH	National Institute of Occupational Safety And Health
NORA	National Construction Agenda
OSH Act	Occupational Safety and Health Act
OSHA	Occupational Safety and Health Administration
OSHRC	Occupational Safety and Health Review Commission
PEL	Permissible Exposure Limit
PFA	Principal Factor Analysis
PPE	Personal Protective Equipment
RIR	Recordable Injury and Illness Incidence Rates
SEM	Structural Equation Modeling
SIC	Standard Industrial Classification
SPSS	Statistical Package for the Social Sciences
TQM	Total Quality management
TSM	Total Safety Management
U.K	United Kingdom
U.S.	United States

CHAPTER 1

INTRODUCTION

1.1 General

In the U.S., construction accidents remain a significant economic and social problem, with over 400,000 injuries and 1,200 deaths annually (BLS 2010). Compared to the high risk sectors, construction involves frequent but relatively small scale accidents, with many and diverse hazard sources. Construction work involves a large number of work processes that need to adapt to the project-specific requirements and context. As a result, construction work processes are loosely-defined, unlike the well-defined procedures of the high-risk systems (such as aviation, nuclear and chemical plants). Furthermore, the complex, dynamic, and often unpredictable construction tasks and environments, combined with high production pressures and workload create high likelihood of errors.

With the continuous pressures for speed, productivity and competitiveness, the challenge for construction researchers and practitioners is to develop work systems that are simultaneously highly productive and highly reliable and can function safely and effectively in the dynamic, complex and competitive conditions of construction projects. (Mitropoulos et al., 2009). This requires a more fundamental understanding of the workplace elements and processes that generate accidents, and new approaches to safety management. In order to achieve a high-performance safety culture, it is critical that construction organizations must not approach construction safety and health as just another step in avoiding unwanted accidents or federal fines, but as a strategic tool, that if implemented effectively, has the potential to maximize competitiveness and profit. This strategic approach to construction safety requires an assessment of safety from a total perspective, i.e. an assessment of all aspects determining the total safety of an organization. This treatment allows a fundamental understanding of the key factor sets that govern safe behaviors of workers, and aids in determining the underlying key factors that control these behaviors.

This integral or total approach to safety can be instrumental in providing excellence in construction safety through continuous improvement by the total involvement and dedication of each individual who is in any way a part of business. It is a structured approach to improvement. If correctly applied, it assists a construction company in continuously improving its total safety performance and achieving the goal of zero accidents in their organizations.

1.2 Background and Motivation

Great strides towards a safe workplace environment have been made in the construction industry over the last few decades. Majority of construction companies have comprehensive safety plans, but the quality of the plan does not necessarily correlate to a company's safety performance. Written safety plans have the potential to be very effective, but companies must go beyond the safety plan and create a true "safety culture" (Hinze, 1997).

Most current safety practices in the construction sector are based on the normative approach (compliance with prescribed safety rules) (Mitropoulos et al., 2009). They focus on measures to control hazards, and means to control workers' behaviors so that they comply with prescribed safe practices. This approach emphasizes (1) management commitment and policies to prevent unsafe conditions and (2) workers' training and motivation to prevent unsafe behaviors. Safety programs – such as contractor's selection, training, inspections, motivation, enforcement, etc., as well as efforts towards safety culture, and behavior-based safety aim at increasing the workers' compliance with prescribed 'safe behaviors.' This approach has resulted in significant improvements, but is still nowhere close to reaching the zero-accident goal.

While the traditional application of normative approach aims at creating safe work behaviors, it ignores how the characteristics of the individual, production system and team processes influence the work behaviors and affect the possibility of errors and accidents (Mitropoulos et al., 2009). First, it does not account for the production and economic pressures for efficiency, and the workers' natural tendency for least effort. Second, the normative approach does not account for the factors that shape the work situations such as, individual commitment of a worker or teamwork practices of a crew. These factors generate the situations the workers face, and the crew's ability to cope with these situations. Rasmussen et al. (1994) explains how the workers' behaviors tend to migrate closer to the "boundary of loss of control" due to two primary pressures: the production pressures for increased efficiency, and the tendency for least effort, which is a response to increased workload. Safety programs attempt to counter the above pressures and prescribe safe behaviors away from the boundary. However, the pressures that push workers toward the boundary require that safety efforts are continuous. From a practical perspective, a key concern is that at the work level, there is a continuous tension between safety and production or costs; in the short term, such conflicts are usually resolved in favor of production, because production efforts have relatively certain outcomes and receive rapid and rewarding feedback (Reason 1990). A study of safety on international projects (Mahalingam and Levitt 2007) also illustrated that economic pressures were stronger determinants of work behavior than the safety regulations.

As a result of these pressures, efforts to improve safety through technical advancements (new methods and improved safety features) tend to be ineffective because the behavior "migrates" close to the new boundary of loss of control (Mitropoulos et al., 2009). Thus, human adaptation compensates for safety improvements. This phenomenon of "risk homeostasis" has been observed in transportation, navigation, and traffic research and explains why technological safety improvements have not generated the expected improvements in safety (Wilde 1985; Fuller 2005). Furthermore, in interdependent systems, the boundary of safe behavior for one actor depends on the possible violation of defenses by other actors (Rasmussen 1997). Thus, the stage for an accident may be prepared as a result of several actors' behaviors that erode the "error margin."

The current safety strategies in construction, which are largely oriented towards technical advancements, have proven to be inadequate for the increasingly competitive and dynamic conditions of the workplace (Mitropoulos et al., 2009). The challenge for researchers and practitioners is to develop total safety systems that are simultaneously highly productive and highly reliable and can function effectively in the dynamic, complex, and competitive conditions that construction projects face. This requires a treatment of safety from a total perspective taking into consideration the impact on safety of organizational work culture, production pressures, team processes, individual characteristics and the like. This treatment will allow a fundamental understanding of the key factor sets that govern safe behaviors of workers, and will aid in determining the underlying key factors that control these behaviors. This would allow a strategic move towards a high-performance and continuously improving safety culture, with the result of achieving and sustaining the goal of zero accidents.

1.3 Problem Statement

The Construction industry, generally, has lagged behind other industries in implementing safety management as a total process for achieving zero accidents and developing a high-performance safety culture. The main reason for this has been the perception that safety as a total management process is hard to implement in the construction industry. One aspect of this total approach to safety that has frustrated the construction industry the most has been "total safety measurement", which involves identifying and measuring the factors that critically influence safe behaviors. The basic problem attributed is the difficulty in assessing what to measure and how to measure it – particularly the intangible aspects of safety. Without measurement, the notion of continuous improvement is hard to follow.

Traditionally, safety on construction sites is measured by level of implementation of safety rules and procedures, and hazard control mechanisms. This systems approach to safety measurement fails to address the "person", "culture", and "behavior" components associated with total safety. Recent advancements in construction safety, such as the move towards "safety culture" and "behavior-based safety" have proven to generate better results; however, these approaches also fail to acknowledge safety as an "integral" or "total" process encompassing multiple dimensions, i.e. person, culture, behavior and process, which cumulatively determine the true safety performance of a construction company. Furthermore, safety performance on construction sites is usually measured using "lagging" indicators (such as accidents) and not by using "leading" indicators (such as safe work behaviors). The effect of adopting these traditional approaches to safety has been three-fold:

1. Construction companies invest all/ major safety related efforts on reducing the number of accidents/ injuries by adopting related control mechanisms and incentive/ disincentive mechanisms based on accidents/ injuries, rather than investing in safety efforts for inculcating total safety in the workforce and adopting measures for "total" safety process analysis and improvement in order to achieve sustainable safety;
    a. Construction companies (and administrative bodies observing their safe behaviors, such as OSHA) measure their safety performance based on number of accidents/ injuries over a certain period of time (number of lost work hours) and not in terms of the company processes being safe or unsafe. Hence the leading indicator to safe performance is taken as "reduced number of accidents" rather than "safe behaviors". It is important to note here that, although the earlier can be a result of good safety performance, it can very well be a representative of accidents not reported or accidents not happening because the near-misses have fortunately not been converted to accidents.
2. Construction workers tend to hide their unsafe acts (injuries) to the extent possible because until they do not reveal their unsafe acts/ injuries to top management, they are likely to be considered as safe workers and will not be punished for unsafe behaviors. This worker attitude shifts their focus from behaving safely to

hiding unsafe acts, which, although may reduce the number of accidents reported, will not help in inducing total safety culture in the workers.

3. Construction workers find themselves working in an environment where, although they usually have an incentive to act safely, do not have any obligation, commitment or motivation to see to it that their co-workers are also behaving safely.

Considering above, it can be inferred that it is a dire need that safety be addressed from the perspective of "total measurement and improvement" rather than from the perspective of "controlling the outcome (accidents)". This need translates to the objective of developing a measurement model – with tools and methodologies for the identification and measurement of factors determining total safety for continuous safety improvement.

Another aspect of this total approach to safety that has frustrated the construction industry is that there exists no common and overarching methodology to implement safety as a total management process. Consequently, contractors do not fully recognize, and realize, the value of strategic safety management as a total process. A direct consequence of this has been that safety is usually considered the responsibility of "safety personnel" (such as safety department, safety director, safety manager, etc.) in an organization and is seldom considered the responsibility of "everyone" in the company. Workers usually do not find themselves responsible for their unsafe acts unless 1) they get converted to incidents, and 2) they are observed as incidents by the safety personnel.

With the above problem statement established, it is obvious to state that it is highly significant to demonstrate how a strategic framework for safety improvement in the construction industry based on an integral or total approach to safety can be developed.

This framework is oriented towards enforcing a total safety culture in construction organizations. The core objective of the framework is to provide a mechanism to measure total safety using leading indicators and improve total safety by improving the underlying factors influencing safe behaviors. This would allow a strategic move towards a high-performance and continuously improving safety culture, with the result of achieving and sustaining the goal of zero accidents.

1.4 Research Hypothesis

It is the premise of this research that individual intentions as well as group culture (corporate safety culture) have as much, or more, to do with the safety performance than the safety program. This research develops itself on an integral approach to safety containing four dimensions (person, culture, behavior and process) that collectively define the interior and exterior pursuits necessary to determine the true safety performance of a construction organization. It is hypothesized that all four pursuits offer complementary, rather than contradictory, perspectives. That is, it is possible for all to be correct and necessary for a complete account of safety existence. Also, each by itself offers only a partial view of reality. Hence an integral or total view of construction safety can only be achieved if integration is made of these four areas of knowledge through an acknowledgement of them as the four fundamental dimensions of safety. The research then endeavors into correlating these total safety dimensions to the safety performance of a company. It is further hypothesized that all four pursuits by their very nature cultivate successful safety performance. While these hypotheses seem intuitive, little research has been conducted to specifically identify and measure critical characteristics as related to all the four dimensions that, in integration, influence safety. This research attempts to quantify the relationship between total safety dimensions and safety performance.

1.5 Research Goal

This research endeavored to develop a strategic framework to continuously improve safety in order to create a high-performance safety culture on construction worksites, with the strategic aim of achieving zero accidents. This framework took an integral or total approach to safety by including the key factors in all four dimensions (person, culture, behavior, and process) that collectively determine the true and total safety performance of a construction organization. Since the framework was based on fundamental issues and endeavored to measure the total safety environment, it is envisaged that the systems developed using the proposed framework would simultaneously be highly productive and highly reliable, in addition to being functioning safely and effectively in the dynamic, complex and competitive conditions of construction projects.

This framework is envisaged to be instrumental for inculcating total safety environment in construction organizations. The core objective of the framework would be to provide a mechanism to measure total safety using leading indicators and improve it by improving the factors influencing safe behaviors. This would allow a strategic move towards a high-performance and continuously improving safety culture, with the result of achieving and sustaining the goal of zero accidents. This approach is contrasting from the traditional approach of treating safety from an "outcome" (accidents) perspective. The framework is simple in nature, facilitating its wide implementation.

1.6 Research Objectives

As mentioned earlier, the primary goal of the study was to develop a strategic framework based on approaching safety as a total process in the construction industry for the measurement and continuous improvement of safety in order to achieve and sustain the goal of zero accidents, while improving the quality, productivity and the competitiveness of the construction industry as it moves forward.

Consistent to the above goal, the objectives of the research study were:

1. To assess the current state of safety in the construction industry and establish the need for addressing safety as a total process in construction contracting organizations;
2. To identify the factors determining the total safety environment of a construction contracting organization, which are most suitable and appropriate for measurement and improvement and hence play a pivotal role in strategic safety improvement; and
3. To develop a strategic framework for defining, measuring, and improving total safety in the construction industry in order to achieve and sustain the goal of zero accidents.

1.7 Scope of Study

Although equally applicable to other construction sectors, the study limited itself to commercial building construction sector only. This was owing to the limited timeframe in which the study needed to get completed.

1.8 Significance of the Research Study

The major significance of this research seeking to develop a strategic safety improvement framework can be related as follows:

1. It is important to manage the multifaceted safety risks associated with construction projects not only to secure work and make profit, but to also act responsibly and provide a safe work environment to the employees.
2. The developed framework can be adopted by U.S. contractors to continuously improve their safety performance and hence achieve the goal of zero accidents.
3. The current financial crisis has put the role of safety risk management in the construction business into focus. For U.S. firms engaging themselves in the construction business, one of the most effective means of mitigating financial risks is through a strategic safety management model.

1.9 Research Methodology

In order to achieve the research objectives, the research process was carried in a two-phase approach. The steps followed in each of the phases are described in the following sub-sections.

The main goal of the study, as stated earlier, was to demonstrate how a total safety framework can be developed for the measurement and continuous improvement of safety in order to achieve and sustain the goal of zero accidents.

1.9.1. Research Phase I

This phase of research was conducted to achieve objective 1 of the study. It consisted of the following tasks.

1.9.1.1. Literature Review

In the initial process of research, a thorough literature study was conducted in order to form a firm basis to develop detailed questionnaire surveys. Published literature on current safety scenario in the construction industry and construction industry safety performance was thoroughly studied. Information gathered was used, in particular, to develop questionnaire surveys targeting construction contractors in the U.S. to assess the following aspects of safety in the construction industry:

1. Current safety attitudes and approaches of contractor management in construction industry,
2. Current safety attitudes and approaches of supervisors and foremen in construction industry,
3. Criticism on OSHA (Occupational Safety and Health Administration) with respect to its lack of success in acting as a catalyst to incorporate total safety in a construction organizations, and
4. State of adoption and implementation of safety as a total management process in a contracting firm's management system.

1.9.1.2. Data Collection

In this phase, detailed questionnaires were developed and sent to construction contractors consistent to achieving objective 1 of the study. This phase provided a comprehensive database and valuable data on the current state of safety in the construction industry.

The results obtained from surveys conducted in this phase of research were analyzed to establish a rationale of the need of addressing safety as a total process in the construction industry. Once the rationale was established, the next phase of research was undertaken.

1.9.2. Research Phase II

The second objective of this research study was to identify the factors which could be instrumental in continuously improving the safety performance of construction projects. These factors were considered under several domains, viz., person, culture, behavior, and process. The factors in each domain were obtained from literature review and expert input. The premise was that when these factors are improved then we can attain continuous safety improvement in the construction industry.

Once the multi-dimensional factors impacting safety performance were established, a zero-accident safety improvement framework was established based on an integral approach to safety. This constituted the third objective of the study. The framework development required collecting relevant data from the industry and applying modeling techniques to develop a measurement and improvement model for total safety in the construction industry.

The framework provides a strategic safety performance evaluation and improvement mechanism for a construction firm and the construction industry. This strategic improvement framework facilitates total safety concepts and techniques to be incorporated into the existing management systems in a contracting organization. Also, it allows a contracting organization to focus its efforts on those factors that would strategically improve safety performance of the organization as well as will provide opportunity for continuous safety improvement and hence achieving and sustaining the goal of zero accidents.

1.10. Results

This research has developed a strategic framework for the construction industry for the measurement and continuous improvement of total safety in order to achieve and sustain the goal of zero accidents, while improving the quality, productivity and the competitiveness of the construction industry as it moves forward, without adding complexity and administrative burden. The developed framework could be used as a tool by the industry to measure and continuously improve safety. It not only provides the construction participants a clear picture of the safety performance of the company, but also identifies areas to be improved. Although the framework was developed based on data collected from the commercial building construction sector in the U.S., the framework is fundamental in nature and is highly adaptable by other sectors of the industry as well by other nations.

1.11 Relevance of Research to Strategic Goals of NIOSH and OSHA

The research has direct relevance with Strategic Goal 8 of the National Construction Agenda (NORA 2008) of NIOSH (National Institute of Occupational Safety And Health). The goal states:

"Increase understanding of factors that comprise both positive and negative construction safety and health cultures; and, expand the availability and use of effective interventions at the policy, organizational, and individual level to maintain safe work practices 100% of the time in the construction industry."

The above strategic goal consists of the following two intermediate goals:

"Intermediate Goal 1: Create a working definition and framework for construction industry safety and health culture and improve understanding of the factors that

contribute to a positive or negative safety and health culture in the construction industry."

"Intermediate Goal 2: Develop and expand the use of validated measurement methods for evaluating safety culture and safety climate in the construction industry"

Also, National Construction Agenda suggests that there is overlap between strategic goal 8 and Safety and Health Management in Construction. Aspects of safety and health management (such as top management commitment, teamwork, production systems) affect safety culture in an organization.

Moreover, the research is also in line with the strategic plan put forward by OSHA (Occupational Safety and Health Administration) (OSHA 2008):

"All OSHA programs are designed to reduce fatalities, injuries, and illnesses, but the approaches differ depending on the circumstances and nature of the underlying cause of the problem. Direct interventions achieve the outcomes by engaging in one-to-one relationships with employers and employees. Direct intervention will always be necessary to ensure workplace safety and health. At the same time, lasting solutions will come about because employers, workers, and many others embrace a workplace safety and health culture. From OSHA's perspective, its resources devoted to realizing this goal have the potential to multiply its effectiveness - by instilling safety and health values among the broad population and enlisting them in pursuing the same goals. Achieving this goal will require concerted effort, enhancement of OSHA's compliance assistance skills, innovation, and continued dedication to safety and health ideals."

1.12 Organization of Dissertation

The dissertation is logically organized into seven (7) chapters and appendices:

Chapter one is the introduction and is composed of background, problem statement, research hypothesis, goal, objectives and scope of study.

Chapter two comprises of literature review on current safety scenario in the U.S. construction industry, safety research paradigms, current safety strategies and limitations, and zero accident approach to safety.

Chapter three describes in detail the methodology followed in this research.

Chapter four discusses phase I of the data analysis process, which was undertaken to determine the need for addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents.

Chapter five discusses phase II of the data analysis process, which was undertaken to identify the factors (latent variables/ constructs) determining the total safety environment of a construction contracting organization, which are most suitable and appropriate for measurement and improvement and hence play a pivotal role in achieving and sustaining the goal of zero accidents.

Chapter six delves into the development of the strategic safety improvement model based on the identified factors and their associated indicators. This model is estimated using structural equation modeling (SEM) technique to identify latent constructs that describe total safety and to quantify relationships among them and between these total safety determinants and safety performance of a construction organization.

Chapter seven summarizes the conclusions of this study and recommendations for further research based on the research findings and insight developed during the course of this study.

The appendices include the questionnaires used in the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Safety record in construction is one of the poorest (Hinze, 2005; Hallowell and Gambatese, 2009; Mitropoulos et al., 2009, Molenaar et al., 2009; Mohamed, 2002). Construction has the highest rate of accidents among all industries (Hinze, 1997; Sawacha et al., 1999; Ahmed et al., 2000). Traditional research in safety has largely focused on the prescriptive approach to safety (safety programs, compliance, rules, management procedures, etc.). Available safety management models invariably revolve around compliance, and more recent models have been developed around safety culture, safety climate, and behavior improvement. However, there have been few studies in the area of total safety and much of this research is of qualitative nature. The discussion in this chapter leads the reader to conclude how the existing research lacks a strategic total approach to safety.

2.2 Current Safety Scenario

The construction industry in the United States accounts for about 10 percent of the gross domestic product, having an annual dollar volume of about $450 billion. The industry employs five percent of the nation’s work force—yet that five percent experiences a disproportionate 20 percent of all traumatic occupational fatalities and 12 percent of the total number of disabling injuries (BLS, 2010).

Accident data prepared by the Bureau of Labor Statistics (BLS, 2010) show that the construction industry has performed much worse than the average of all industries. Although the safety performance of the construction industry has improved dramatically in the 1990s and 2000s, injury rates in the construction industry are still 50% higher than that of all industries, lagging all industries by about 10 years. With an average employment of approximately 7% of the industrial workforce, the construction industry has regularly accounted for over 1,100 construction worker deaths per year or nearly 20% of all industrial worker fatalities (www.bls.gov). These accidents have also resulted in great economic losses. The research conducted by Everett and Frank (1996) concluded that the total costs of construction accidents accounted for 7.9–15.0% of the total costs of new, nonresidential projects. A more recent research study by Coble and Hinze (2000) showed that the average workers' compensation insurance costs could be conservatively estimated as constituting 3.5% of the total project costs. In order to reduce and eventually eliminate construction accidents, researchers have explored techniques implemented by different construction parties to realize the "zero-injury objective."

Research shows that development and implementation of effective safety programs reduce accidents. Unfortunately, when it comes to spending time and money on safety, many do not feel safety is vital to the success of their projects. This attitude stems from a failure to recognize that effectively implementing project safety techniques will, while reducing job injuries, also reduce the workers' compensation premium by 50 to 90 percent and the indirect costs of injury by a like amount (CII, 1993).

In the last couple of decades, the industry has taken major steps in identifying and eliminating the causes of accidents on construction sites. On many construction sites, safety has become one of the most important emphasis areas. Construction firms are realizing that the initial investment, and the continuous efforts to maintain a good safety record, do pay off by not only reducing injuries on the job site, but by also contributing to an “on time” and “within budget” project delivery.

The larger construction companies have generally been the most aggressive firms in pursuing the goal of zero accidents. Many of these firms are the pacesetters and therefore, the safety record and the way safety is structured in these firms are of great importance to the construction community. It is the large construction firms in the United States that have made important strides toward improving construction safety. The strides in safety are so significant that injury frequency rates that were once the goals of firms have now become unacceptable levels of safety performance for many firms.

Despite recent improvements and a number of success stories, the safety performance of the construction industry, in general, remains poor (Hinze, 2008; Hallowell and Gambatese, 2009; Mitropoulos et al., 2009; Molenaar et al., 2009; Mohamed, 2002) and is far from achieving the goal of incident and injury free environment (a.k.a. zero accidents). It is important to investigate as to why the safety performance of the construction industry is not up to par. This investigation requires a fundamental understanding of the various safety research paradigms as explained in the next section.

2.3 Safety Research Paradigms

Rasmussen (1997) identifies three paradigms in the evolution of research on accidents and occupational safety. The first paradigm focuses on normative, prescriptive theories concerning the way people ought to act. Efforts to prevent occupational accidents focus on task design and safe rules of conduct—they attempt to control behavior through normative instruction of the ‘one best way,’ selection and development of ‘competent’ personnel, and motivation and punishment. The current safety practices in the construction sector are grounded on this safety paradigm (Mitropoulos et al., 2009).

The second paradigm focuses on descriptive models of work behavior in terms of deviations from the normative, ‘best way’ of working—that is errors and biases. This paradigm guides efforts to control behavior by removing causes of errors. It includes studies of errors (Rigby 1970, Rasmussen et al.1981), management errors and resident pathogens (Reason 1990).

The third paradigm takes a cognitive approach to safety. The cognitive approach focuses on the interaction of the individual and the work system. It is concerned with the characteristics of the work system (the features of the task, tools and environment) that influence the individual decisions and actions and the possibility of errors (Rasmussen et al. 1994). From a cognitive perspective, an error is not a ‘human failure’ but a symptom of a problem in the work system (Dekker 2005). This paradigm provides descriptive models of work behavior in terms of the behavior-shaping features of the work environment. Such models include the risk homeostasis theory (Wilde 1985), Rasmussen’s (1997) model of migration to accidents, and the Task-Capability Interface Model (Fuller 2005). The cognitive approach to safety attempts to prevent accidents by increasing the workers’ ability to successfully adapt to the work environment. It aims at making visible the constraints and work affordances of the workplace (Flach et al. 1998).

Most current safety practices in the construction industry are based on the normative approach, which has its own strategic limitations as discussed in the next section.

2.4 Current Safety Strategies and Limitations

The current safety practices in the construction industry are mostly based on compliance with prescribed safety rules. They focus on measures to control hazards, and means to control workers' behaviors so that they comply with prescribed safe practices. "A systems approach to safety" label term is widely used in literature (Flin et al. 2000) to refer to this normative approach to safety. It encompasses all aspects of the organization's safety management system including safety policies, procedures, committees, etc. This system provides a systematic process for planning, implementing, monitoring, and reviewing safety performance. Elements of the construction safety system include safety policy and objectives, safety standards and targets, planning and organization of work, implementation and normal operational practice, monitoring, feedback and audits, corrective action, review, and continual improvement. The systems approach to safety has been the core of research in construction safety.

This systems approach emphasizes (1) management commitment and policies to prevent unsafe conditions and (2) workers' training and motivation to prevent unsafe behaviors. Safety programs—such as contractor's selection, training, inspections, motivation, enforcement, etc., as well as efforts towards safety culture, and behavior-based safety aim at increasing the workers' compliance with prescribed 'safe behaviors.' This approach has resulted in significant improvements, but is still far from reaching the zero-accident goal.

While the traditional application of normative approach aims at creating safe work behaviors, it ignores how the characteristics of the individual, team and production system processes influence the work behaviors and affect the possibility of errors and accidents. First, it does not account for the production and economic pressures for efficiency. Second, the normative approach does not account for the factors that shape the work environment such as individual commitments, cultural norms, attitudes and perceptions of an individual and group, etc. These factors generate the environment the workers work in, and the crew's ability to continuously and consistently perform safely.

With regard to production and economic pressure, from a practical perspective, there is a continuous tension between safety and production or costs at the work level; in the short term, such conflicts are usually resolved in favor of production, because production efforts have relatively certain outcomes and receive rapid and rewarding feedback (Reason 1990). A recent study of safety on international projects (Mahalingam and Levitt 2007) also illustrated that economic pressures were stronger determinants of work behavior than the safety regulations. As a result of these pressures, efforts to improve safety through technical advancements (new methods and improved safety features) tend to be ineffective (Mitropoulos et al., 2009) because human adaptation compensates for safety improvements. This phenomenon of "risk homeostasis" has been observed in transportation, navigation, and traffic research and explains why technological safety improvements have not generated the expected improvements in safety (Wilde 1985; Fuller 2005). Furthermore, in interdependent systems, the boundary of safe behavior for one actor depends on the possible violation of defenses by other actors (Rasmussen 1997). Thus, the stage for an accident may be prepared as a result of several actors' behaviors that erode the "error margin."

With regard to factors that shape the work environment such as individual commitments, cultural norms, attitudes and perceptions of an individual and group, these factors interact with the systems and produce work behaviors that may prove to be unhealthy or unsafe. Efforts to improve safety through systems and technical advancements (without an integral treatment of these factors) tend to be ineffective because the behavior change is only temporary and is not usually sustainable.

Hence the current safety strategies in construction, which are largely oriented towards systems advancements and behavior control, prove to be inadequate to achieve and, more importantly, sustain the goal of zero accidents because of these fundamental flaws in the approach.

The key challenge for researchers and practitioners is to develop total safety systems that are simultaneously highly productive and highly reliable and can function effectively in the dynamic, complex, and competitive conditions that construction projects face. This requires a treatment of safety from an integral perspective taking into consideration all dimensions of safety and their inter-dependence. This treatment will allow a fundamental understanding of the individual, organizational and production system characteristics that govern both the safe behaviors of workers and the effectiveness of safety systems, and will aid in determining the underlying factors that control the true total safety performance of a company.

Recent research in safety (mostly in the last two decades or so) has targeted safety culture, safety climate and behavior based safety as significant contributors/ measures of safety performance of a construction organization. This direction of safety research has generated fruitful results and is discussed in the next section.

2.5 Safety Culture, Climate and Behavior Based Safety Research

A generic definition of corporate culture is helpful in the understanding of safety culture. Hampden-Turner (1990) define corporate culture as "a pattern of basic assumptions in vented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration that has worked well enough to be valid and to be taught to new members as the correct way to perceive, think, and feel in relation to these problems." Numerous other definitions of corporate culture exist in the academic literature. Examples of a few selected definitions are tabulated in Table 2.1.

Table 2.1: Selected Corporate Culture Definitions

Reference	Definition of corporate culture
Hai, 1986	Corporate culture is a collection of uniform and enduring beliefs, customs, traditions, and practices that are shared and continued by the employees of a corporation.
Maloney and Federle, 1990	Corporate culture is a collection of shared beliefs that define the fundamental characteristics of an organization and create an attitude that distinguishes one organization from all others.
Graves, 1986	Culture is the unique configuration of norms and attitudes that characterize the manner in which employees combine to accomplish tasks.
Kotter and Heskett, 1992	Corporate culture refers to the values held by employees of an organization that tend to persist even when membership changes.

Corporate culture is instrumental in an organization's success. It provides the workplace environment for the employees of an organization. When people work in an environment that they perceive as rewarding, they are more likely to perform at a high level. Furthermore, a company's success is the result of the organization performing certain tasks very well (Maloney and Federle, 1990). Corporate culture is what determines these work environments, as well as the tasks in which an organization excels.

Safety culture can be considered as a particular aspect or subset of corporate culture. Strictly speaking, the organization (or one of its subunits) has one underlying culture, and that culture has characteristics that may be more or less supportive of safety, quality, productivity or any other performance target. Thus, a more useful formulation than talking about the safety culture is to ask whether an organization's culture is supportive of safety. Yet definitions of the term “safety culture” exist in literature and the tem is often coined when describing the subset of organizational culture that affects workers’ attitudes and behaviors in relation to an organization’s ongoing safety performance.

The Advisory Committee on the Safety of Nuclear Installations (ACSNI 1993) provides the definition that “the safety culture of an organization is the product of group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to and the style and proficiency of an organization’s health and safety management.” Numerous definitions of safety culture exist in the academic literature. Examples of a few selected definitions are tabulated in Table 2.2. Most of the definitions are relatively similar in their belief perspectives, with each focused, to varying degrees, on the way people think and/or behave in relation to safety. Though definitions vary, there is a consensus of safety culture being a proactive stance towards safety. This now has been almost universally accepted if not always practiced (Lee and Harrison, 2000; Choudhry et al., 2007).

Table 2.2: Selected Safety Culture Definitions

Reference	Definition of safety culture
Hale (2000)	Safety culture refers to "the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems."
Guldenmund (2000)	Safety culture is defined as those aspects of the organizational culture that will impact on attitudes and behavior related to increasing or decreasing risk.
Cooper (2000)	Culture is "the product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational); while safety culture is 'that observable degree of effort by which all organizational members direct their attention and actions toward improving safety on a daily basis."
Mohamed (2003)	Safety culture is a subfacet of organizational culturethat affects workers' attitudes and behavior in relation to an organization's ongoing safety performance.

Zohar (1980) introduced "safety climate" as "a summary of molar perceptions that employees share about their work environment." Researchers considered it as a subcomponent of the safety culture (Cooper, 2000; Neal et al., 2000; Choudhry and Fang 2005) and a reflection of actual safety culture (Lee and Harrison, 2000; Flin et al., 2000; Guldenmund, 2000). Mohamed (2003) suggested that safety culture is concerned with the determinants of the ability to manage safety (top-down organizational approach); whereas, safety climate is concerned with the workers' perceptions of the role safety plays in the workplace (bottom-up perceptional approach). Thus, culture is something that is more deeply embedded and long term, taking longer to change and influencing organizational performance across many areas of functioning. Climate, on the other hand, changes faster and more immediately reflects the attention of leadership. As specific events occur that influence the organization, the climate for safety (or for any other factor) changes. The most striking example is the impact on safety climate immediately following a serious injury or fatality. Most of the time, such an event triggers a strengthening of the safety climate. However, this change often does not last over the long term.

Behavior-based safety (BBS) refers to the systematic application of psychological research on human behavior. It is an analytic or data-driven approach, where critical behaviors get identified and targeted for change. In BBS, primary attention is directed at specific safety-related behaviors that are, typically, performed by workers (Krause et al. 1984). Workers' performance gets systematically observed to know base-period scores. Using these scores, goal-setting meetings are arranged, with the participation of workers, to set realistic and attainable targets of performance. Workers are encouraged to practice safe behaviors. Providing feedback is essential to reinforce desired safety behaviors, thus fostering continuous improvement. It is noteworthy that more than 80% of all workplace accidents and incidents are attributed to unsafe behaviors (HSE, 2005).

In recent years, there has been a movement away from safety measures purely based on retrospective data or "lagging indicators," such as accident rates, toward so-called "leading indicators," such as measurements of safety climate (Flin et al. 2000; Mohamed, 2002). The shift of focus has been driven by the awareness that organizational, managerial, and human factors rather than purely technical failures are prime causes of accidents (Weick et al. 1999; Langford et al., 2000; Mohamed, 2002) developed a model to examine and assess relationships between safety climate determinants and the safety climate in construction site environments, and the correlation between the safety climate and workers' safe behavior. Molenaar et al. (2009) developed a model to measure critical cultural characteristics that influence safety and to quantify the relationship between culture and safety performance. Grote and Kunzler (2000) presented a sociotechnical model of safety culture that links the safety management system and safety culture to the general organizational design. Geller (1994) put forward a model distinguishing three dynamic and interactive factors, namely, person, behavior, and environment. Three years later, a total safety culture model, which included this safety triad and recognized the dynamic and interactive relationship between them, was proposed (Geller 1997). Cooper (2000) argued that organizational culture is the product of multiple goal-directed interactions between people, jobs, and the organization, and presented a model recognizing the presence of an interactive or reciprocal relationship between psychological, situational, and behavioral factors. Choudhry et al. (2007) integrated three related concepts, namely, safety climate, behavior-based safety, and safety system, into a safety culture model allowing different dimensions of construction safety culture to be measured individually or in combination.

A previous safety research of note that provided the stimulus to this research was that by Molenaar et al. (2009), which developed a structural equation model of corporate culture as it affects safety performance. This research was based on the hypothesis that construction safety performance (measured by EMR – Experience Modication Rating) is predictable on the basis of corporate safety culture. The research proposed that construction organizations can have inherent characteristics that predispose them to be susceptible to accidents. The characteristics that influence corporate safety culture were classified into three main categories: (1) people; (2) process; and (3) value. The primary results of the study can be summarized by stating that corporate safety culture is significantly related to safety performance. From an integral strategic perspective of safety, the limitations of this research study were: 1) the study only looked at the "culture" domain of the fundamental domains defining total safety; 2) the study used a lagging indicator (EMR) to measure safety performance; and 3) the data collected to develop the model was limited. The research in hand attempts to overcome these limitations and builds upon a large data set, considers an integral view of all fundamental total safety dimensions (person, culture, behavior and process), and uses a leading indicator (safe work behavior) to measure safety performance.

Another research study of note that also provided stimulus for this research was that conducted by Mohamed (2002), which examined the relationship between the safety climate and safe work behavior in construction site environments. This study also utilized the technique of structural equation modeling to come up with a relationship model between safety climate determinants and safety performance (as measured by safe work behaviors). From an integral strategic perspective of safety, the limitations of this research study were: 1) the study looked at the "culture" (in fact climate) and the "behavior" domains of the fundamental total safety dimensions; 2) the study ignored interaction effects between the factors determining the safety climate; and 3) the study was only based on data collected from construction workers and did not take into account the perspectives of top management and supervisors. The research in hand attempts to overcome these limitations and builds upon an integral view of all fundamental total safety dimensions (person, culture, behavior and process), considers the interaction effects between the factors determining total safety, and basis itself on a large data set with data collected from top management, supervisors, foremen, and construction workers.

While all these models are intuitive and have addressed safety from a cultural, climate or behavior-based perspective, they still lack a total approach to safety i.e. an approach that would take into consideration the entire personal, group, behavioral, process and production system factors as an integrated model determining the true total safety performance of a construction organization. Furthermore, objective measurement and improvement of total safety (as identified by all dimensions defining and determining total safety) remains a concern yet to be addressed by prior research. This very gap in the body of knowledge concerning construction safety is the motivator that proved to be the driving factor for the research in hand.

2.6 Effectiveness of OSHA as a Strategic Safety Improvement Organization

In the United States, all construction safety is legislated by the Occupational Safety & Health Administration (OSHA), a federal agency that is part of the U.S. Department of Labor, which was created by the Congress under the Occupational Safety and Health Act in 1970. Credible statistics reveal that OSHA has had a beneficial influence on the US construction industry in terms of reducing workplace accidents and occupational injuries. Undoubtedly, OSHA has played a pivotal role in the development of a safer work environment over the years. Nevertheless, the agency still has received substantial criticism from construction organizations for a number of reasons. Even though the number of workplace accidents and casualties has dropped down drastically in the construction industry ever since OSHA regulations have been implemented, construction firms have viewed OSHA's regulations and standards in a negative light as well. This is despite the numerous attempts by the agency to promote training, consultation, and outreach services.

One of the more common arguments against OSHA is that its heavy fines and ambiguous standards restrict an organization's ability to develop as well as compete. An analysis of OSHA citations that were contested by employers before the Occupational Safety and Health Review Commission (OSHRC), for the years 1991–1993 (reported in the *Occupational safety and health reporter* published by the Bureau of National Affairs, and comprised of 255 citations) shows that in the majority of the OSHA citation cases, the arguments centered around the vagueness in the interpretation of OSHA standards. Several standards, for example, simply read that the employer must provide safety equipment. While the employer interpreted this to mean ''make available,'' OSHA interpreted it to mean ''require use of.'' A further analysis of these citations reflects that a significant increase in the dollar amounts penalized is seen from 1991–1992 to 1993. This was due to the new minimum sevenfold increase in penalties implemented by OSHA to make the impact of its citations a clear priority to contractors. Larger penalties presumably draw more attention from construction companies, and they may be more willing to allocate adequate money for safety programs to avoid these lofty penalties. However, it also entails the industry view that OSHA is more concerned with generating revenues (via penalties) than strategically improving safety in the industry.

Assessing the issues why OSHA has not been completely successful in achieving and sustaining the goal of zero accidents in the construction industry is important in terms of determining the need of a strategic safety improvement framework for the industry targeted towards incident and injury free work environment. Existing literature fails to identify these issues and hence the current study would delve into highlighting the key concerns with respect to OSHA's lack of performance.

2.7 Zero Accident Approach to Safety

In the past decade the terms "zero accidents", "zero injuries" and "incident and injury free" have been used a great deal by construction firms espousing their commitment to safety. Studies have shown that many construction firms, especially those in the industrial sector, have enjoyed significant improvements in their safety performances. These performance statistics have been considerably better than those of the overall construction industry and provide clear testimony of the effectiveness of efforts to improve safety.

With the advent of increasing numbers of owners and contractors who are achieving zero lost workday injuries on construction projects, a new concept is emerging – zero injury. This new-found reality for some has become a sought-after possibility for others. Zero injury defines a unique attitude on projects achieving the category of "safety excellence." This attitude appears as a zealous commitment by top management to the concept that zero injury is the only acceptable goal. Any other goal implies that injuries are expected and acceptable. The zero injury concept simply means that essentially all serious injury to workers can be successfully prevented.

The zero injury philosophy is based on the belief that eliminating all worker injuries on projects for significant periods of time is possible. The first essential criterion required is the acceptance of the zero injury concept by those in charge and the effective communication of this to the workers. Further, it is essential that owners and contractors devote resources for the development and implementation of the safety techniques that provide the highest impact on achieving zero injury projects. The construction industry needs to recognize that elimination of injuries is vital to the efficient execution of construction projects, and that productivity and safety are so intertwined in the workplace, that spending time and energy on safety not only improves safety performance but also improves schedule and reduces costs.

In 1993, the CII released its report on zero accidents, called Zero Injury Techniques (CII, 1993). From this study, evolved the five high-impact zero accident techniques, summarized as follows, in decreasing order of relative importance:

1. Preproject/ pretask planning for safety
2. Safety orientation and training
3. Written safety incentive programs
4. Alcohol and substance abuse programs
5. Accident/incident investigations

In 1998, the National Center for Construction Education and Research and the M. E. Rinker Sr. School of Building Construction at the University of Florida conducted a survey to examine changes made since the zero accidents research was publicized. The purpose of the study was to further assess the status of the safety performance of large construction companies and to identify the-then best practices in the construction industry that made a difference in safety performance and that move the industry toward the goal of zero accidents.

The results generated by the study reconfirmed the importance of several traditional safety methods and techniques employed by the construction industry and it also identified some effective new techniques. These findings are summarized in the following ten key areas that contribute to improved safety performance:

1. Demonstrated management commitment
2. Staffing for safety
3. Planning: pre-project and pre-task
4. Safety education: orientation and specialized training
5. Worker involvement
6. Evaluation and recognition/reward
7. Subcontract management
8. Accident/incident investigations
9. Drug and alcohol testing
10. Contract Type

While the idea of zero accidents is intuitive, not much research has been done specifically in terms of developing a strategic safety improvement model for the construction industry that would allow continuous measurement and improvement of factors determining the safety performance of a construction organization, and hence would be instrumental in reaching and sustaining the goal of zero accidents. Hence the current study would delve into developing such a model directed towards the goal of zero accidents.

2.8 Total Safety Management

Total Safety Management (TSM) bears its roots from Total Quality Management (TQM), which is ingrained on Deming's Fourteen Points. Although not much research has been done on TSM in construction industry, for the last couple of decades, TSM philosophy has found its way in construction safety research (Geller, 1994; Geller, 1997; Hinze, 2005). TSM focuses on safety as an integral process, not the management of safety, on continuous improvement of process in order to improve every facet of an organization. The implementation of TSM is fundamentally a process of culture change. Although 'Total Safety Management' has been a magic word, methods and techniques to implement Total Safety in an Industry are still to be developed. Moreover, no accurate information regarding the adoption and implementation of TSM in the construction industry is available. Hence the current study would delve into establishing the current state of adoption of TSM in the construction industry and the readiness of the construction organizations to embrace TSM philosophy.

Much of the research done on TSM in construction industry has been of qualitative nature. One aspect of TSM that has frustrated the construction industry the most has been "measurement" of total safety, which involves identifying and quantifying the factors that critically influence safe work behaviors. The basic problem attributed is the difficulty in assessing what to measure and how to measure it – particularly the intangible aspects of safety. Without measurement, the notion of continuous improvement is hard to follow. Hence the need of the research in hand was pre-established i.e. to develop a strategic framework for the measurement and continuous improvement of total safety in order to achieve and sustain the goal of zero accidents, while improving the quality, productivity and the competitiveness of the construction industry as it moves forward.

The key challenge for researchers and practitioners is to develop total safety systems that are simultaneously highly productive and highly reliable and can function effectively in the dynamic, complex, and competitive conditions that construction projects face. This requires a treatment of safety from an integrated perspective taking into consideration all fundamental dimensions of safety and their inter-dependence. This treatment will allow a fundamental understanding of the individual and organizational characteristics that govern both the safe behaviors of workers and the effectiveness of safety systems, and will aid in determining the underlying factors that control the true safety performance of a company.

2.9 An Integral Entity Model

Ken Wilber (Wikipedia, 2011) defines four dimensions for every entity. Each entity or unit of reality that is both a whole and a part of a larger whole, has an interior and an exterior. It also exists as an individual and (assuming more than one of these entities exists) as a collective. Observing the entity from the outside constitutes an exterior (objective) perspective on that entity. Observing it from the inside is the interior (subjective) perspective, and so forth. If these four perspectives are mapped into quadrants, these constitute four quadrants, or dimensions as depicted in Figure 2.1.

The above concept leads to defining four dimensions of every entity: 1) Behavioral i.e. exterior individual (or, in Figure 2.1, the upper-right); 2) Intentional i.e. interior individual (upper-left); 3) Cultural i.e. interior collective (lower-left); and 4) Process i.e. exterior collective (lower-right).

All four pursuits – behavioral, intentional, cultural and process – offer complementary, rather than contradictory, perspectives. It is possible for all to be correct and necessary for a complete account of human existence. Also, each by itself offers only a partial view of reality. Further, according to Wilber, these four perspectives are equally valid at all levels of existence.

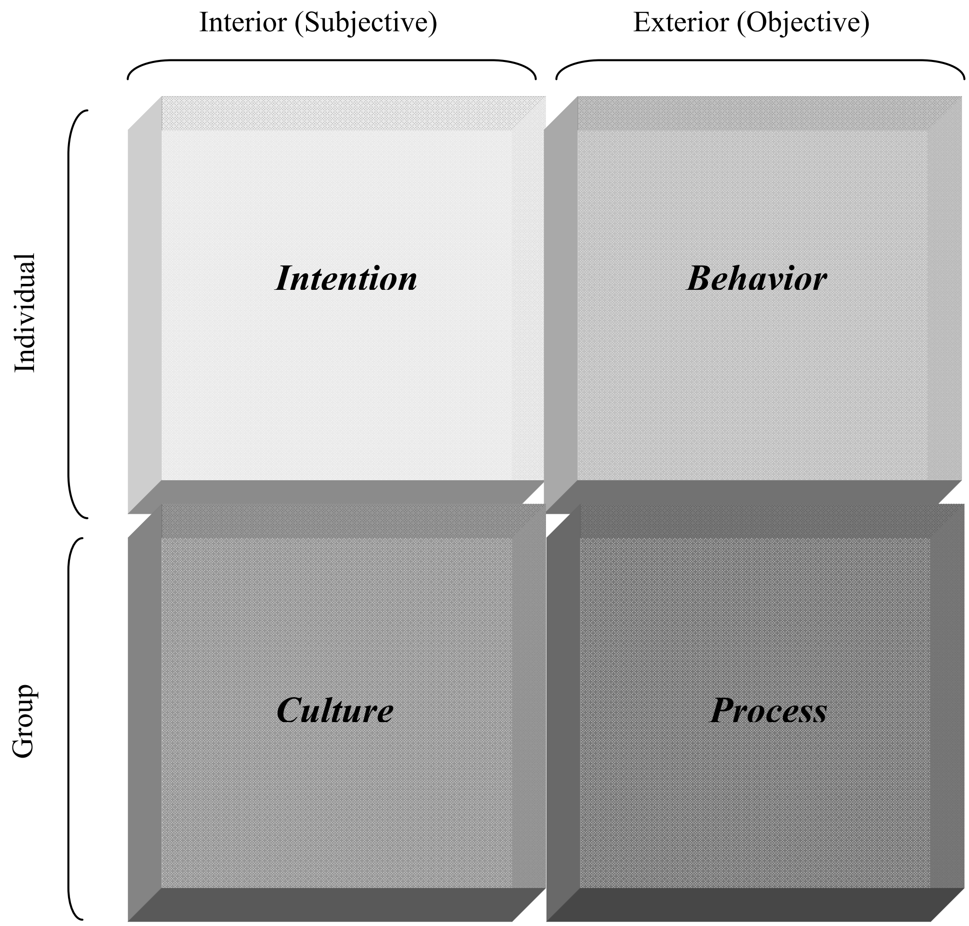

Figure 2.1: Integral Entity Model (adapted from the work of Ken Wilber)

Note that the right sides of the quadrants are concerned with empirical observation—what does it do? The left sides of the quadrants focus on interpretation—what does it mean?

This integral entity model forms the basis of the current research and will be discussed more in the following chapters.

2.10 Concluding Remarks

Literature review shows that a vast amount of research has been conducted on construction safety in the past few decades. Recent advancements have been made in viewing safety as a cultural issue. OSHA has played its part and has done extremely well in terms of reducing workplace accidents. However, safety research to date in the construction industry lacks a total treatment of safety as a strategic concern in business value. These limits are creating barriers to improved construction safety. There are a number of signs of this phenomenon, such as the invisible "vision," where the corporate safety policy has little to do with the day-to-day functional issues of safety. Safety performance reporting is typically limited to meeting regulatory-driven information requirements. Rarely is it recognized as a potentially effective means of communicating positive safety results. And, regardless of the quality of the company's safety performance, the basic relationship with the relevant regulatory agencies is still largely adversarial in nature. Companies must realize that they can benefit from voluntary initiatives and potential "partnering" arrangements where mutual interests with regulators may exist. Viewed in this light, even the current leaders in construction safety management will need to make important changes in their existing management systems. They must cultivate a vision for the future that elevates safety concerns and effectively integrates them into the overall management mix. For this very reason, a need for a strategic approach to safety improvement is called for, which forms the premise of this research.

It is the premise of this research that individual intentions, commitments, group culture, and work behaviors have as much, or more, to do with the safety performance than the safety management system. This research develops itself on an integral approach to safety (as explained in section 5.3) that collectively define the interior and exterior pursuits necessary to determine the true total safety environment of a construction organization. It is hypothesized that an integral view of construction safety can only be achieved if integration is made of these areas of knowledge through an acknowledgement of them as the fundamental dimensions of safety. It is further hypothesized that all safety pursuits by their very nature cultivate successful safety performance. While these hypotheses seem intuitive, literature review has highlighted that little research has been conducted to specifically identify and measure critical characteristics as related to all the dimensions that, in integration, define as well as influence total safety. This forms the core aim of this research.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The literature review discussed in Chapter 2 provides a background of the various facets of the current body of knowledge in relation to construction safety and highlights the lack of a comprehensive integral model of continuous strategic total safety improvement in the construction industry. Based on the information gathered from the literature review a specific research methodology was developed and is described in this chapter.

More elaborately, this chapter outlines the specific research methodology employed in the development of the strategic model for continuous safety improvement in the construction industry, including the data collection procedures, survey instruments development, and data analysis techniques. Various statistical test procedures including structural equation modeling technique were used in the research investigation.

The data for this research was collected through the use of five (5) surveys targeting construction contractors in the U.S. in order to achieve the following three (3) objectives:

1. To assess the current state of safety in the construction industry and establish the need for addressing safety as a total process in construction contracting organizations in order to achieve the goal of zero accidents;
2. To identify the factors (latent variables/ constructs) determining the total safety performance of a construction contracting organization, which are most suitable

and appropriate for measurement and improvement and hence play a pivotal role in achieving the goal of zero accidents; and

3. To develop a measurement model to measure the effect of the key determinants of safety performance (the critical factors) on a construction organization's safety performance.

In order to achieve the research objectives, the research process was carried in a two-phase approach. The steps followed in each of the phases are described in the following sub-sections.

3.2. Research Phase I

3.2.1. Literature Review

In the initial process of research, a thorough literature study was conducted in order to develop the research rationale as well as form a firm basis to develop survey instruments to be used in the study. Published literature on current safety scenario and strategies in the U.S. construction industry was thoroughly studied, with particular emphasis on current safety statistics, prevalent safety management practices of construction contractors (policies, procedures, programs, systems, etc.), safety performance measurement and improvement, safety culture & climate measurement and improvement, use of behavior-based safety techniques in construction, role, success and criticism on OSHA (Occupational Safety and Health Administration), zero accident strategies in construction, and the move towards Total Safety Management (TSM) in construction industry. Furthermore, studies were done to identify what other developed countries (like U.K., Australia, Singapore, Hong Kong, etc.) have been doing and achieving in terms of construction worker safety.

3.2.2. Data Collection Phase I

3.2.2.1. Scope and Relevance to Study Objectives

This phase of data collection was undertaken to achieve objective 1 of the study, i.e. to determine the need for addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents. This objective (objective 1 of the study) had four key sub-objectives as defined below:

1. To evaluate the current safety attitudes and approaches of contractor management in construction industry,
2. To evaluate the current safety attitudes and approaches of supervisors and foremen in construction industry,
3. To analyze the state of success (and failure) of OSHA (Occupational Safety and Health Organization) as a regulatory agency to incorporate safety as a total process in construction organizations; and
4. To investigate the state of adoption and implementation of safety as a total management process in a construction contracting firm's management system, and to identify the benefits and obstacles.

3.2.2.2. Data Collection Method

Knoke and Bohrnstedt (1994) define data collection as an activity of developing primary data records for a given sample or population of observations. Babbie (1992) discussed different modes of data collection including experimental, survey, unobtrusive and evaluation. Because survey research involves collecting data through asking people questions, it was deemed the most appropriate method of data collection for this phase of the study.

3.2.2.3. Survey Research

The survey research employed in this phase of the study has a fundamental characteristic as described by Fowler (1993): Collecting information by asking questions to industry personnel with industry & project experience in safety.

The survey research was done via structured questionnaires and interviews from industry experts. A synopsis of the methodology adopted for safety spot analysis is given as follows:

1. Identifying the key areas of safety concern (research aspects) to be investigated.
2. Developing and conducting surveys for each area of concern. For each research aspect, the survey development and administration methodology consisted of the following steps:

   1.1 Conducting relevant literature review i.e. collecting base knowledge essential for survey development.

   1.2 Developing questionnaire surveys targeted to construction contracting organizations/ workers to elicit information on the research aspect being diagnosed.

   1.3 Conducting pilot surveys via face-to-face meetings with selected professionals including short-listed experts representing contractors and various staff levels of contracting organizations, with the objective to fine tune the survey instruments on the basis of expert feedback.

   1.4 Administering full-fledged questionnaire surveys through postal mail, electronic mail, fax, personal interviews and meetings.

1.5 Validating returned questionnaires (in terms of respondent profile and consistency of feedback).

2. Developing a centralized database system to store the collected data from structured surveys for the purpose of analysis, and structuring the data in the database.
3. Analyzing the data to compile the findings.
4. Devising conclusions from the findings and developing recommendations consistent with the major objective of this phase of data collection i.e. to determine the need for addressing safety as a total management process in construction contracting organizations.

The research methodology for each area of concern can be represented as a flowchart as shown in Figure 3.1.

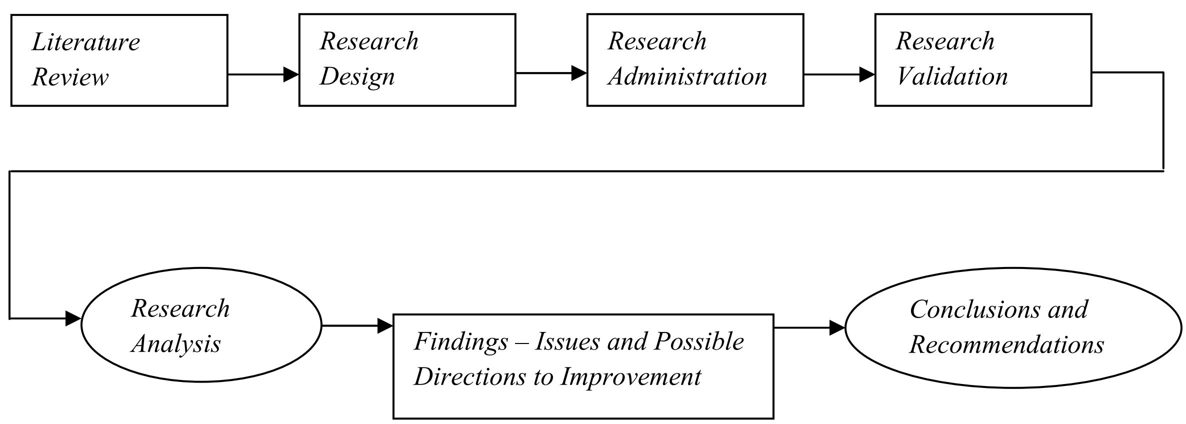

Figure 3.1: Research methodology – Research Phase I

The methodology is described in more detail in the following sub-sections.

3.2.2.3.1. Identifying Key Areas of Safety Concern

Consistent to the four sub-objectives of objective 1 of the study, the following four (4) key areas of concern related to construction safety were identified via preliminary literature review for further investigation:

1. Current safety attitudes and approaches of contractor management in construction industry,
2. Current safety attitudes and approaches of supervisors and foremen in construction industry,
3. OSHA – success, barriers and limitations;
4. Safety as a total management process in construction industry – adoption, implementation, readiness, benefits and obstacles.

3.2.2.3.2. Survey Development, Administration and Validation

3.2.2.3.2.1. Survey Instruments Development

Extensive literature review provided the base information on each of the four (4) key areas of safety concern (as identified in section 3.2.2.3.1), which was used to develop the following four (4) surveys for this research as part of Data Collection Phase I .

1. Evaluation of the current safety attitudes and approaches of contractor management in construction industry;
2. Evaluation of the current safety attitudes and approaches of supervisors and foremen in construction industry;
3. Analysis of the state of success (and failure) of OSHA (Occupational Safety and Health Organization) as a regulatory agency to incorporate safety as a total process in construction organizations; and

4. Investigation of the state of adoption and implementation of safety as a total management process in a construction contracting firm's management system, and to identify the benefits and obstacles.

3.2.2.3.2.2. Pilot Surveys

Subsequent to the development of each survey instrument, pilot surveys were conducted via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their top management and middle/ project management, all having expertise in or exposure to safety issues. The intent of these pilot surveys was to pretest the questionnaires on select professionals so as to obtain such versions of the surveys (after appropriate modification in each as and if needed) that would achieve acceptable levels of measurement reliability and validity. With input from these local contractor representatives, the questionnaires were appropriately modified to best capture the information specific to research needs. The first section of the first questionnaire collected company demographic information, which was analyzed using both qualitative and quantitative techniques. The survey included questions regarding the company's location, nature of work, number of employees, annual turnover, etc. The entire set of questionnaires is given in Appendix I.

3.2.2.3.2.3. Survey Administration

3.2.2.3.2.3.1. Survey Method

Data gathering is complex. So, the decision on which survey method depends on the particular research topic, characteristics of the sample, and availability of staff and resource (Fowler 1993). Assessing the methodologies for data collection against the objective of this phase of the research led to the determination that questionnaires send by electronic mail and postal mail with as-necessary follow-up telephone calls were the most suitable for this phase of research work. Because of the nature of structured interviews, it was determined that these would best be achieved by in-person interviews, However, because of geographic constraints many were done by telephone. For the questionnaire component of data gathering, telephone or facsimile correspondence were used only when the response to the questionnaire was behind scheduled due dates, or when the respondents contacted the researcher with questions or requests for further information.

An exhaustive list of industry contractors was prepared as a first step of survey administration. Various published and unpublished sources were used to develop a list of commercial construction contractors in the U.S. construction industry. This identification was done, in particular, from the following sources:

1. Engineering News Record (ENR) publications, including the list of Top 500 U.S. Contractors;
2. The general contractors list published by the Associated General Contractors (AGC) of America; and
3. A customized list of general contractors and subcontractors prepared from the yellow pages, trade magazines and other published and unpublished sources.

3.2.2.3.2.3.2. Data Sample

The theoretical population of this phase of research was the top management, senior project managers, and safety managers/officers of all general contracting firms as well as subcontracting firms in the United States. No limits on the size of construction firms or annual turnover of the construction firm were established. There were not a minimum number of years of experience an individual should have to qualify to be a participant.

This population description is in line with the major objective of this phase of research i.e. to assess the current state of safety in the construction industry and determine the need for addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents.

The final data sample was selected by a combination of sampling methods. The researcher first used purposive sampling. In purposive sampling "the participants are hand-picked from the accessible population" (Gliner & Morgan, 2000). The participants were selected because of their experience as senior corporate and project managers for commercial construction firms. Firstly, the liaison of Florida International University (FIU) with the local construction industry was utilized for selecting appropriate construction companies. Secondly, since many of the government organization (counties and cities) employees are students at FIU Construction Management (CM), Civil and Environmental Engineering (CEE) and other engineering departments, these employees were approached first hand for their voluntary contribution in the research. Thirdly, the CM department at FIU also has an advisory committee made up of a number of large commercial construction contractors in the South Florida region. These advisory committee members were also approached first hand with the request to voluntarily contribute to the research.

Convenience sampling was also used to solicit participants for this phase of the research. In convenience sampling, "the participants are selected on the basis of convenience rather than chosen in a serious attempt to select participants who are representative of the theoretical population" (Gliner & Morgan, 2000). Senior managers working for companies in Florida to which the researcher had access were given the opportunity to volunteer for participation. In some cases the companies were known to the researcher and in other cases the companies were randomly selected from the three sources identified above.

Snowball sampling was also used. "Snowball sampling is a modification of convenience or accidental sampling …. People are asked for additional references" (Gliner & Morgan, 2000).

The major chunk of data was collected using random sampling. According to good survey practice (Tull and Hawkins, 1990), a letter was sent to the Chief Executive/ Managing Director of companies randomly selected from the three sources of identification indicated above. This letter was sent to introduce the research and request voluntary input. Referred to in the letter was a request for names of the key personnel associated with safety management processes and safety decision making in the companies, who would subsequently be canvassed for opinions.

The surveys were carried out over the period extending from September 2008 to February 2009. The questionnaires were posted to named individuals in September 2008, with a suggested date for return at the end of November 2008. Questionnaires returns were received over the next five months, in some cases after a phone call reminder.

3.2.2.3.2.3.3. Delimitations

The focus was delimited to general contractors and specialty contractors with major experience in commercial building construction. In future studies, research may be expanded to other types of construction such as residential, heavy-civil, or industrial.

3.2.2.3.2.4. Survey Validation

Research validation was done in three steps.

Firstly, it was confirmed that the survey was filled by personnel with appropriate profile and experience. Construction industry experience of respondents ranged from 9 to over 28 years, and all participants had at least 11 years of experience in construction safety. On the basis of their position and work experience, it was inferred that the respondents had adequate knowledge of safety related activities in their organizations as well as in the industry and their responses were a reasonable representation of required data.

Secondly, to avoid the problem of bias, it was decided not to use data provided by an organization with less than 5 responses on a particular survey. Based on this decision, the following was determined:

1. Data from six (6) companies was discarded for survey instrument 1, since a total of 19 responses were received from these companies for survey instrument 1;
2. Data from five (5) companies was discarded for survey instrument 2, since a total of 14 responses were received from these companies for survey instrument 2;
3. Data from three (3) companies was discarded for survey instrument 3, since a total of 7 responses were received from these companies for survey instrument 3; and
4. Data from four (3) companies was discarded for survey instrument 4 since a total of 11 responses were received from these companies for survey instrument 1.

Moreover, 18 questionnaires were determined to be outliers and were also decided to be discarded. Hence a total of 69 questionnaires were discarded from the analysis.

Thirdly, the conclusions drawn on the basis of the responses were further verified through interviews with experts to ascertain that they were unbiased. Twelve (12) face-to-face unstructured interviews were conducted in the vicinity of Miami, Florida from a selected cross-section of local construction industry experts to discuss the results and validate the findings. The targeted audience included top management and middle management representatives of leading contractors and subcontractors working in the commercial building construction sector in the South Florida region.

The survey instruments generated quite substantial and valuable data on the current state of safety performance in the U.S. construction industry, specifically, the safety non-performance causes. The results obtained were particularly useful in developing the rationale of the need of an integral model of construction safety with the objective of continuously improving safety to reach the goal of zero accidents.

3.2.2.3.2.5. Developing the Database and Data Analysis Mechanism

Appropriate data storage mechanisms were developed and the data stored for the purpose of analysis. Statistical Package for Social Sciences (SPSS) was used to categorically compile and sort the data collected in the form of filled questionnaires, minutes of meetings, interviews, etc.

Tables and Forms collecting data on SPSS were interfaced with Microsoft Excel for the purpose of data analysis. Data analysis was done using SPSS and major findings compiled.

3.3. Research Phase II

Phase II of the research was consistent in achieving objectives 2 and 3 of the study. The scope and relevance of this phase of research with the study objectives is explained below.

The second objective of this research study was to identify the factors which could be instrumental in continuously improving the safety performance of construction organizations. This was achieved as follows.

Based on the findings of the phase I of research, the research premise was established that an integral or total approach to safety was essential to determine the factors instrumental for total safety improvement in the industry. Further literature review enabled to outline four dimensions of construction safety with respect to a construction worker as an entity: 1) behavior i.e. exterior individual; 2) person i.e. interior individual; 3) culture i.e. interior collective; and 4) process i.e. exterior collective. These dimensions collectively define the interior and exterior pursuits necessary to determine the true safety performance of a construction organization. It was envisaged that an integral view of construction safety can be achieved if integration is made of these four areas of knowledge through an acknowledgement of them as the four fundamental dimensions of safety.

Defining the interior as well as exterior pursuits to safety was a complex task. This research began by decomposing safety dimensions into measurable attributes using a multiattribute analysis technique. Through expert interviews and an exhaustive literature review, a multiattribute hierarchy of safety pursuits was defined. The highest level of the hierarchy decomposed safety into four principal dimensions, viz., intent, culture, behavior and process. These four categories were then subdivided and decomposed into measurable safety characteristics that formed the basis of a questionnaire to measure safety.

This study adopted safe work behaviors (observable actions) as the safety performance indicator. This selection was based on the justification that that leading indicators are better measures of safety performance than lagging indicators. Traditional measures of safety performance rely primarily on some form of accident or injury data. The main problems are that such data are insufficiently sensitive, of dubious accuracy, retrospective, and they ignore risk exposure. Although accident statistics are widely used throughout the construction industry, it is almost impossible to use accidents as a safety indicator for a single construction site. This is because of random variation, where many sites will have no accidents, and it is not possible to determine whether these sites with zero accidents are safer than sites with four or five accidents.

The questionnaire contained two sections: Part I constituted statements to measure safety characteristics, while Part II consisted of items to measure safe work behavior as the safety performance indicator. To the extent possible, the different statements used in developing the questionnaires were drawn upon scales that had been previously used by researchers. To achieve acceptable levels of measurement reliability and validity, draft questionnaires were constructed and pretested on a few graduate students and a few construction safety managers. Their input was used to refine the original questionnaire. The questionnaire contained, in its final form, a total of 140 statements (138 statements listed in Part I and 2 statements listed in Part II) about safety issues at the organizational, group, and individual levels. A number of negatively worded statements were presented in the scale, as recommended in the measurement literature.

A survey methodology was selected to collect data regarding the dimensions of safety because it offered the best opportunity to capture a cross section of the beliefs, values, systems and behaviors in multiple companies in a timely and efficient manner. As the survey sample, the research targeted top management, senior project managers, safety managers/officers, supervisors, foremen, and construction workers of general contracting firms as well as subcontracting firms. This is in line with the major objective of the research – seeking a correlation between total safety determinants and safe work behavior in construction organizations. Appropriate modifications were made in the questionnaire in order to address the various levels of respondents (from field personnel to middle management to upper management).

The data analysis technique used was structural equation modeling (SEM). Before the SEM analysis began, a rough estimate of the latent variables (factors) was derived from a confirmatory factor analysis. A principal factor analysis (PFA) using the varimax rotation method with Kaiser normalization was utilized. Based on the factor analysis results, the 23 subcategories defined for the domains of factor sets were reduced into 6 factors (latent variables/ constructs/ underlying dimensions). The research premise was that when these factors are improved then we can attain continuous safety improvement in the construction industry.

Once the multi-dimensional factors impacting safety performance were established, a base structural equation model (SEM) was developed following the broad hypothesis that safe work behaviors (and, thus, their reciprocal, unsafe behaviors) are consequences of the existing safety dimensions in a construction organization, which is determined by the inter-dependent factors identified earlier. Hypothesis was developed for each of the factors/ constructs to define paths in the structural model. Numerous iterations were performed to arrive at a final SEM specification. Hence a zero-Accident safety improvement framework was established based on an integral approach to safety, which constituted the third objective of the study. Note that objective 3 of the dissertation had two sub-objectives:

1. To develop a measurement model describing the relationship between the indicators and the factors.
2. To develop a structural model describing the relationships amongst the factors, and the relationships between the factors and safety performance (as measured by safe work behavior).

The program used for SEM analysis was AMOS (version 19.0). Both the measurement model and the structural model were developed using SEM analysis on AMOS. The initial SEM was constructed using various combinations of the factor analysis results and then model improvements were performed using a combination of modification indices and solid theoretical support until a final satisfactory model was identified. In essence, asymptotic *t*-statistics and *R-square* goodness of fit (GOF) measures were employed to assess the regression equations in the model.

Both the measurement and structural components of the SEM provided insight into the influence of total safety determinants on safety performance. The discussion is given in chapter 6 of the dissertation.

It is envisaged that the framework developed would provide a strategic safety performance measurement and improvement mechanism for a construction firm. This strategic improvement framework would allow a contracting organization to focus its efforts on those factors that would strategically improve safety performance of the organization as well as would provide opportunity for continuous safety improvement and hence achieve the goal of zero accidents.

The methodology flow chart for the entire research effort is shown in Figure 3.2.

3.4 Summary

This chapter outlined the background information collected, development of the Safety improvement framework, and the design and administration of the data collection instruments used in this research. The structured interviews used to determine background information, and the subsequent framework development process took approximately 16 months. The data collection was accomplished in two phases. The overall process of data collection took almost a year to complete. Statistical techniques such as factor analysis and structural equation modeling were undertaken to analyze the data and verify the research hypotheses. The following chapter discusses background information on the two major analysis techniques used during the study, i.e. confirmatory factor analysis and structural equation modeling.

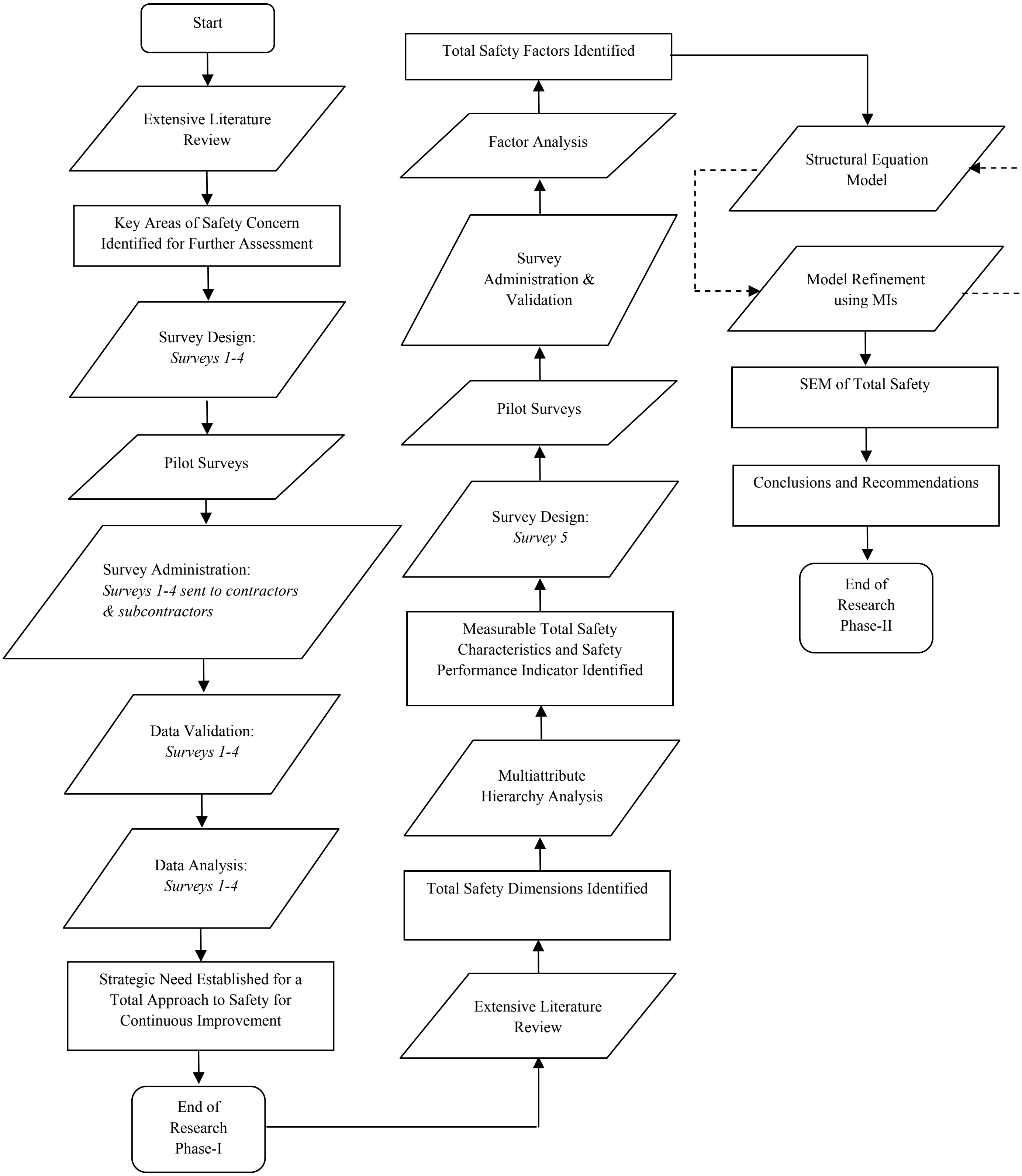

Figure 3.2: Research methodology – Overall Research

CHAPTER 4

DATA ANALYSIS PHASE I

4.1 Introduction

In chapter 3, the methodology implemented to conduct this research endeavor was discussed. This chapter discusses phase I of the data analysis process, which was undertaken to achieve objective 1 of the study, i.e. to establish the need of addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents.

To establish the need of addressing safety as a total management process, the following two specific research questions were deemed significant to address, which determined the key tasks at hand:

1. Are the safety strategies currently employed by industry participants helping in strategically improving safety in construction organizations?
    - Task 1: Assess contractor management attitudes and approaches
    - Task 2: Assess supervisor-level attitudes and approaches
    - Task 3: Assess OSHA's lack of performance
2. Are the current safety improvement strategies instrumental in nurturing total safety in construction organizations?
    - Task 4a: Investigate the state of adoption and implementation of total safety in a contracting firm's management system.
    - Task 4b: Investigate the readiness of construction organizations to embrace total safety.
    - Task 4c: Investigate the barriers towards implementing total safety.

To achieve the aforementioned tasks, survey research was done via structured questionnaires and interviews from industry experts. Extensive literature review provided the base information on each of the four (4) tasks constituting the key areas of safety concern (as identified in section 3.3.2.3.1), which was used to develop the following surveys for this phase of research:

1. Assessment of current safety attitudes and approaches of contractor management in the construction industry;
2. Assessment of current safety attitudes and approaches of supervisors and foremen in the construction industry;
3. Analysis of the criticism on OSHA (Occupational Safety and Health Organization) with respect to its lack of success in acting as a catalyst to incorporate total safety in construction organizations; and
4. Investigation of the state of adoption and implementation of safety as a total management process in construction contracting firms' management systems, and to identify the obstacles.

This chapter outlines the data collection and analysis process of each of the four surveys conducted in this phase of research. This begins with a brief description of the survey instruments and a discussion of the data collection process. This is followed by assessing the survey response rates and respondents' profile. Subsequent to this, a detailed description of each survey along with a discussion of the key results is presented. This is done with particular emphasis to their utility towards establishing the rationale of the research i.e. determining the need for addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents.

4.2 Brief Description of Survey Instruments and Utility toward Overall Research Objective

4.2.1. Survey Instrument 1: Assessment of Current Safety Attitudes and Approaches of Contractor Management in the Construction Industry

Contractor management plays an important role in organizing and implementing safety policies on construction sites (Mohamed, 2002). The interaction and communication of management with workers in terms of their commitment, support and motivation can have a positive (or negative) influence on workers' perceptions, attitudes, competence, and behaviors towards safety.

The objective of this survey was to assess the current safety attitudes and approaches of the top management of U.S. construction contracting firms in terms of providing commitment and support for implementation of key safety management policies, procedures and practices. Conclusions drawn from this research were to strengthen or weaken the argument that contractor management in construction organizations in the U.S. is generally focused towards safety compliance rather than safety participation.

From the perspective of the overall aim of this dissertation, the underlying intent of this specific study was to collect and analyze data on contractor management attitudes and practices, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous and sustainable safety improvement.

4.2.2. Survey Instrument 2: Assessment of Current Safety Attitudes and Approaches of Supervisors and Foremen in the Construction Industry

The construction supervisor/ foreman is typically the key person of contact for workers in the field on a construction project. This person is responsible for the direct daily supervision of activities with the key task is to see that all work elements are fitted together in the right sequence and at the right time. The supervisor plays an important role in organizing and managing productivity, quality, and safety outcomes.

The objective of this survey was to assess the current safety attitudes and approaches of supervisors and foremen in U.S. construction contracting firms in terms of providing commitment, support and training/ coaching for promoting safety among workers and in the work environment. Conclusions drawn from this research were to strengthen or weaken the argument that the supervisors (and foremen) in construction organizations in the U.S. are generally focused towards safety compliance rather than safety participation.

From the perspective of the overall aim of this dissertation, the underlying intent of this specific study was to collect and analyze data on the attitudes and practices of construction supervisors and foremen, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous and sustainable safety improvement.

4.2.3. Survey Instrument 3: Analysis of the Criticism on OSHA with Respect to its Lack of Success in Acting as a Catalyst to Incorporate Total Safety in Construction Organizations

Empirical evidence exists that, over the years, organizations have viewed OSHA and their numerous regulations, standards, and strict penalties in a negative light. One of the more common arguments against the agency is the fact that their heavy fines and guidelines deliver an overbearing and unwanted presence that greatly restricts an organization's ability to develop as well as compete. This places a heavy burden on organizations by forcing increased operational fees and the costs associated to retrofit outdated equipment rather than investing on improving the processes for achieving long-term safety objectives. A similar argument is that the agency is not actively participating in the necessary research to view and incorporate safety as an industrial development process, and hence their regulations do not support implementing safety as a total management process.

This research collected industry opinions in order to more elaborately assess the criticism on OSHA with respect to its failure to act as a catalyst to incorporate total safety in a construction organization. In particular, the research attempted to delve into the reasons as to why OSHA has not been as successful as it should have been.

From the perspective of the overall aim of this dissertation, the underlying intent of this specific study on OSHA was to collect and analyze data on OSHA criticism, which was to serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous and sustainable safety improvement.

4.2.4. Survey Instrument 4: Investigation of the State of Adoption and Implementation of Safety as a Total Management Process in Construction Contracting Firms' Management Systems, and to Identify the Obstacles

Today's construction projects are growing in complexity and in order to succeed on the global level, construction organizations must not approach construction safety and health as just another step in avoiding unwanted accidents or federal fines, but as a strategic tool, that if implemented effectively, will have the potential to maximize competitiveness and profit. This strategic approach to safety can be accomplished via a total management approach to safety.

Literature review highlighted that no accurate information regarding the extent of usage of safety as a total management process in the construction industry was available. Hence this survey was conducted wherein the contractors and subcontractors were asked to identify the extent of adoption and implementation of safety as a total management process in their businesses. The results of the survey included measurements on the extent of knowledge of the industry personnel about safety as a total management process, and the use of techniques of implementing safety as a total management process in the industry. The survey further reflected industry opinions as to the benefits and obstacles of the application of total safety techniques to the construction industry in terms of achieving the goal of zero accidents.

Conclusions drawn from this study were to strengthen or weaken the argument that the safety improvement strategies currently adopted by construction organizations in the U.S. are generally focused towards safety compliance rather than total safety management.

From the perspective of the overall aim of this dissertation, the underlying intent of this specific study was to collect and analyze data on safety improvement practices, and Total Safety Management adoption and readiness, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety improvement framework in the construction industry to achieve continuous and sustainable safety improvement.

4.3 Survey Administration

The surveys were carried out over the period extending from September 2008 to February 2009. The questionnaires were posted to named individuals in September 2008, with a suggested date for return at the end of November 2008. Questionnaire returns were received over the next five months, in some cases after a phone call reminder.

The four surveys were administered via a consistent set of data sample of construction contractors and sub-contractors. More specifically, the final data sample included general contractors, structural steel contractors, poured concrete contractors, precast concrete contractors, masonry contractors, electrical contractors, mechanical and HVAC contractors, etc. representing 102 different companies (37 general contractors and 65 specialty contractors) working in the building construction sector (commercial and institutional). These 102 companies selected shared many common traits. They were mostly medium to large size firms on the basis of their employee counts and annual turnovers; they all performed all or some of their own work (such as carpentry, concrete placement, masonry work, etc.); they all primarily concentrate on large commercial buildings; and all were willing to actively take part in data collection.

The focus was delimited to general contractors and specialty contractors with major experience in commercial building construction. In future studies, research may be expanded to other types of construction such as residential, heavy-civil, or industrial.

4.3.1. Survey Response

Over 2120 copies of the four questionnaires (approximately 530 each) were distributed to the identified companies through electronic and postal mail. To avoid the problem of bias, it was decided to collect data from no less than 5 employees working for the same organization. A total of 817 questionnaires were returned. However, 69 questionnaires were either determined to be outliers or were discarded owing to possibility of bias. A total of 738 questionnaires were input into an SPSS database to be used for analysis. Overall survey response rates for each of the four surveys (in terms of individual participation) are depicted in Table 4.1. Table 4.2 provides a breakdown of responses in terms of organizational participation.

Table 4.1: Overall response rates

	Total questionnaires distributed	Questionnaires returned	Total number of potential responses	Total valid responses received	Percentage of valid responses
Survey 1	530	212	212	192	36.22%
Survey 2	530	197	197	174	32.83%
Survey 3	530	223	223	201	37.92%
Survey 4	530	185	185	171	32.26%
Total	2120	817	817	738	34.81%

Table 4.2: Breakdown of responses with respect to type of organization

Type of Organization	Approached	Responded	Response %
General Contractor	128	37	28.91%
Subcontractor	183	65	35.52%
Total	311	102	32.80%

The survey response rates depicted in Tables 4.1 and 4.2 (34.81% for individual participation and 32.80% for organizational participation) are very good for a construction industry questionnaire survey and should not be considered as biased (Akintoye and Macleod). In similar type of surveys, Panthi et al. (2007) received a response rate of 19.4%, Ahmed and Azhar (2004) received 30.4% and Wang et al. (2004) received a very low response rate of 7.75%. Baker (1998) reported that statistically reliable conclusions can be obtained from a sample size of 20 or more. Moreover, the conclusions drawn on the basis of the responses were further verified through interviews with experts, and hence can be considered as unbiased.

4.3.2. Respondent Organizations' Profile

Figure 4.1 depicts information about distribution of respondent organizations in terms of their nature of work.

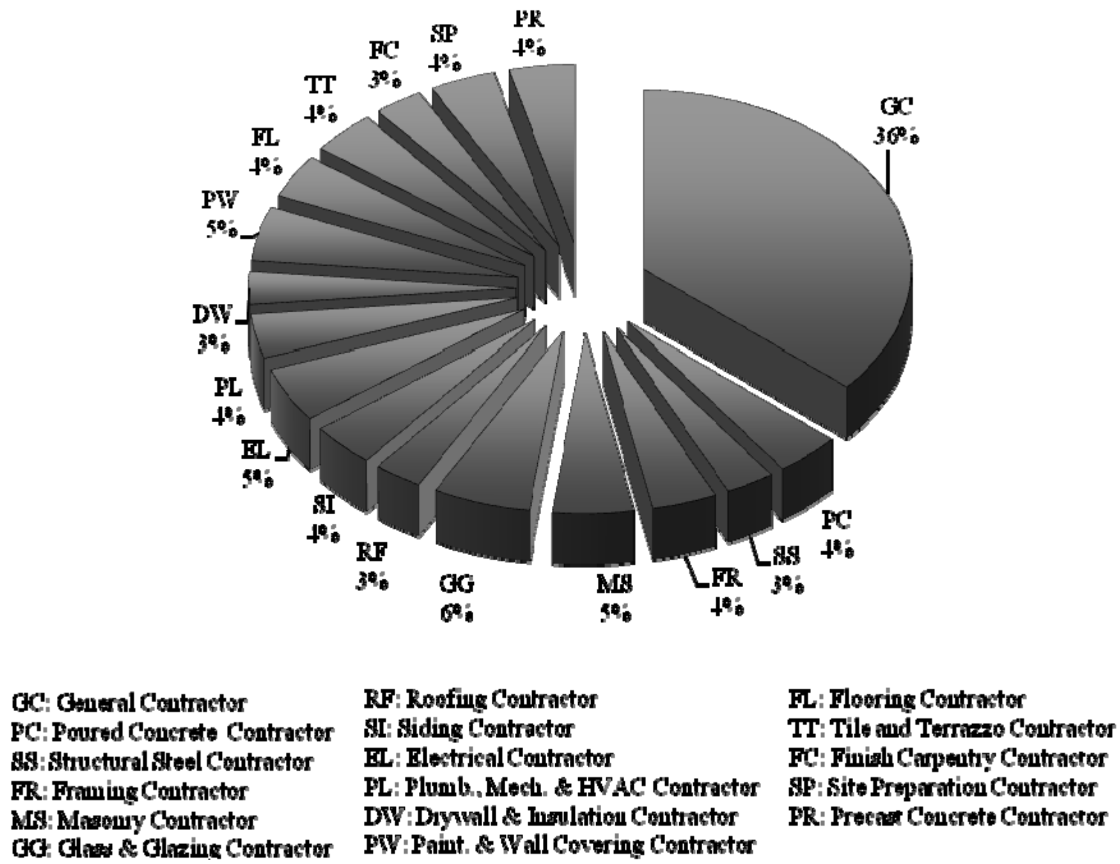

Figure 4.1: Nature of work of Respondent Organizations

Figure 4.2 depicts information about the size of respondent organizations. The organization size is decided on the basis of number of employees as follows: 0-50→small; 51-250→medium; and >250→large. The results indicate that the majority of respondents are medium and large size companies. The annual turnover of these companies varies from $5 million to over $50 million.

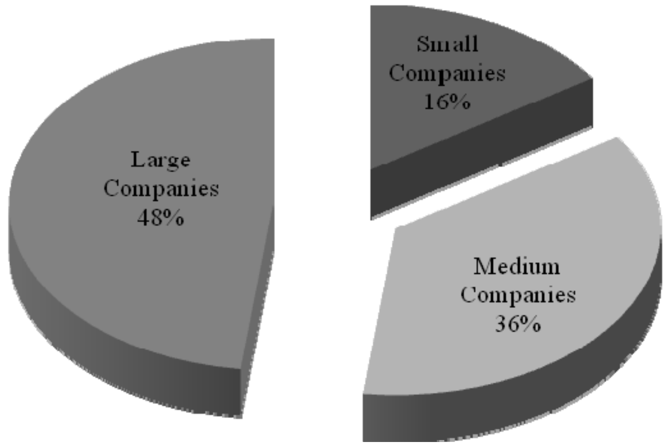

Figure 4.2: Size of Respondent Organizations

Table 4.3 depicts information about the geographic profile (states of operation) of respondent organizations. Most of the organizations had multi-state operations with major or minor businesses in more than 4 states. The average number of organizations surveyed per state was 10.9 with a high of 35 (for Florida) and a low of 5 (for Washington D.C.).

Table 4.3: Geographic Profile (states of operation) of Respondent Organizations

State	No. of Participating Firms	State	No. of Participating Firms	State	No. of Participating Firms	State	No. of Participating Firms
AL	11	IA	9	NV	8	SD	12
AZ	8	KS	11	NH	7	TN	11
AR	9	KY	12	NJ	11	TX	18
CA	18	LA	14	NM	12	UT	12
CO	6	ME	13	NY	22	VT	7
CT	7	MD	12	NC	16	VA	9
DE	8	MA	8	ND	13	WA	11
DC	5	MI	10	OH	7	WV	8
FL	35	MN	7	OK	8	WI	11
GA	18	MS	6	OR	5	WY	9
ID	12	MO	9	PA	6		
IL	14	MT	11	RI	7		
IN	11	NE	12	SC	10		

Table 4.4 shows the collective distribution of respondent organizations In terms of the four regional divisions defined by the United States Census Bureau. It is evident from Table 4.4 that all the four regions share a reasonably balanced distribution of participation (the average share of participation of firms per state per region is 2.04% with a high of 2.30% (for region 3) and a low of 1.82% (for region 1).

Table 4.4: Geographic Profile (regions) of Respondent Organizations

Region	Share of Participating Firms (No.)	Share of Participating Firms (%)
Region 1 (Northeast) – 9 states	88	16.42%
Region 2 (Midwest) – 12 states	126	23.51%
Region 3 (South) – 17 states	210	39.18%
Region 4 (West) – 11 states	112	20.90%

4.3.3. Demographic Information

Middle management (mainly project managers and safety directors) and upper management (mainly vice presidents and senior managers) completed surveys 1, 3 and 4, while supervisors and foremen completed survey 2. Demographic information for the survey respondents is presented in Tables 4.5(a) and 4.5(b).

Table 4.5a: Participants' construction experience (Surveys 1, 3 & 4)

	Average Years	Most Experience	Least Experience
Years in Construction	29.42	38	12
Years as Executives/ Managers	17.68	27	5

Table 4.5b: Participants' construction experience (Survey 2)

	Average Years	Most Experience	Least Experience
Years in Construction	23.17	29	9
Years as Supervisors/ Foremen	12.54	23	5

Table 4.5(a) shows that the average construction experience of the participants for surveys 1, 3 and 4 was 29.42 years with a high of 38 years and a low of 12 years, while the average executive construction experience was 17.68 years with a high of 27 years and a low of 5 years. The average construction experience that these participants had before moving into the executive role was approximately 12 years.

Table 4.5(b) shows that the average construction experience of the participants for survey 2 was 23.17 years with a high of 29 years and a low of 9 years, while the average supervisor-level or foremen-level construction experience was 12.54 years with a high of 23 years and a low of 5 years. The average construction experience that these participants had before moving into the supervisory/ foremen role was approximately 10 years.

Table 4.6 presents the educational qualification of the participants. This wide range of formal education among the participants did not produce a wide range of differences in the data.

Table 4.6 shows that more than 80% of the participants had postsecondary degrees. A further diagnosis of the major concentrations for the postsecondary degrees held by these participants indicated that, including Civil Engineering and Architecture, 58.5% of the participants with a postsecondary degree had that degree in a construction related concentration (such as construction management, construction engineering and the like), 24% of the participants had that degree in business concentration (such as business administration and the like), while the remaining had diverse academic backgrounds ranging from majors in English, Psychology, Education, etc.

Table 4.6: Participants' education

	Number of Participants	Post-Master's Degree	Master's Degree	Bachelor's Degree	Associate's Degree	Some College (No Degree)	High School Degree
Survey 1	192	12	54	89	21	10	6
Survey 2	174	0	12	25	86	35	16
Survey 3	201	17	48	103	18	9	6
Survey 4	171	11	37	97	14	7	5
Total (%)	738	40 (5.42%)	151 (20.46%)	314 (42.55%)	139 (18.83%)	61 (8.27%)	33 (4.47%)

On the basis of their position, education, and work experience, it can be inferred that the respondents have adequate knowledge of the safety related activities in their organizations as well as in the industry.

Overall, the data set (Table 4.6) accounts for a reasonable representation of the companies participating in this study, and produces statistically significant results as described later in this study.

In accordance with established survey procedures and in recognition of the sensitive nature of the data collected, strict confidentiality was maintained during this survey research and no identities have been divulged.

4.4 Data Analysis

4.4.1. Survey 1: Assessment of current safety attitudes and approaches of contractor top management in the construction industry

4.4.1.1.Survey Description

Corporate management plays an important role in organizing and implementing safety policies on construction sites (Mohamed, 2002). The interaction and communication of management with workers in terms of their commitment, support and motivation can have a positive (or negative) influence on workers' perceptions, attitudes, competence, and behaviors towards safety. O'Toole (2002) proposed that there is a connection between management's approach to safety and employees' perception of how important safety is to the management team. For instance, the management approach to safety generates as well as reinforces employee perceptions about what gets rewarded, supported and expected in a particular setting. Neal et al. (2000) identified two distinct management approaches to safety: 1) safety compliance, which involves requiring adherence to safety procedures and carrying out work in a safe manner, and 2) safety participation, which involves supporting and helping workers, promoting the safety program within the workplace, demonstrating initiatives, and putting efforts into safety for improving the safety performance. Hence the management approach/ attitude towards safety must be taken into account while addressing the safety performance of a construction organization.

For the purpose of this study, the evaluation of safety attitude of management in the industry was done by conducting a safety attitude survey in construction organizations that examined the management approaches and practices as a predictive tool to demonstrate how safety is operational within the construction organizations in the industry. A survey was designed and distributed to contractor and subcontractor top management for assessing the overall safety attitudes in their companies by taking into account their safety policy, commitment and support , responsibility structures, communication and authority, decision making, training and orientation, administration and procedures, inspections, accident investigation and reporting, and safety non-performance issues. Conclusions drawn from this research will strengthen or weaken the argument that the top management in construction organizations in the U.S. is generally focused towards safety compliance rather than safety participation.

From the perspective of the overall objective of this dissertation, the underlying objective of this study on contractor top management was to collect and analyze data on top management attitudes and practices, which served as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous safety improvement.

4.4.1.2.Methodology

Structured surveys were conducted to achieve the study objectives. The methodology of survey development and administration was the same as discussed in section 3.2.2.3.

The following sections illustrate the major findings of the research conducted for the key question at hand: Are the strategies, approaches, methods and operations currently employed by contractor top management helping in strategically improving safety in the construction industry?

4.4.1.3.Data Collection

On the basis of literature review, six key constructs (factors) were identified along with a number of associated indicators (observable items in terms of survey questions) to analyze contractor top management attitudes and approaches with respect to strategically improving safety in their organizations. The constructs are described in the following sub-section.

4.4.1.3.1. Constructs

The following six constructs (factors) were used to analyze the various facets of contractor top management attitudes and approaches towards safety.

4.4.1.3.1.1.Safety Policy

This construct consisted of various indicators determining the nature of safety policies in construction organizations, such as, presence of a written safety program manual and field manual, constituent elements of the policy, communication of the policy to the workforce, policy review and revision procedures, and safety criterion in recruitment policy of workers, managers, supervisors, subcontractors, suppliers, and vendors.

4.4.1.3.1.2.Management Commitment and Support

The role management plays in promoting safety cannot be overemphasized. Management's role has to go beyond organizing and providing safety policies and working instructions. Several studies show that the management's commitment and involvement in safety is the factor of most importance for a satisfactory safety level (Jaselskis et al. 1996). Langford et al. (2000) found that when employees believe that the management cares about their personal safety, they are more willing to cooperate to improve safety performance. Thus, the greater the level of management commitment toward safety, the more improved the safety performance. This construct consisted of a number of indicators determining the nature and extent of management commitment and support towards safety in construction organizations. These included demonstrated emphasis of safety over productivity, setting of corporate safety goals, executive management involvement in safety activities, executive management review process on safety, employee empowerment to providing feedback on health and safety matters, continuous support for updating health and safety procedures, presence of a safety responsibility structure at the organizational level, presence of project safety committees, delegation of authority to safety officers to respond independently in case of unsafe acts, provision of appropriate safety support personnel on work sites, and safety performance evaluation of supervisors.

4.4.1.3.1.3.Safety Communication and Decision Making

Management is expected to use a variety of formal and informal means of communication to promote and communicate its commitment to safety (Baxendale and Jones 2000). Simon and Piquard (1991) suggests that both management communication and employee feedback are critical for suggesting safety improvements and reporting near misses as well as unsafe conditions and practices. Thus, the more effective the organizational communication dealing with safety issues, the more improved the safety performance. This construct consisted of a number of indicators determining the nature and effectiveness of safety communication and decision making by top management in construction organizations. These included requirement of site managers and supervisors engage themselves in regular safety talks with operatives, presence of formal behavior observation programs on work sites, encouragement provided to workers to raise safety concerns with their supervisors, a work environment provided by management wherein safety problems are openly discussed between workers and supervisors, involvement of workers in preparation of site safety plans, communication of lessons learned from accidents to workers, and involvement of workers and subcontractor representatives in site safety decisions

4.4.1.3.1.4. Safety Training and Orientation

Training is a major component of safety. Safety training can modify worker safe behavior; the workers can understand the work potential hazard such that they can prevent it (Hallowell and Gambatese, 2009). This construct consisted of a number of indicators determining the nature and effectiveness of safety training and orientation procedures provided by management in construction organizations. These included presence of a health and safety training program/ plan, review and revision process of the training program, levels of training focused in the program, inclusion of safety training as a line item in project budget, requirement for conductance of site safety orientation for every new person to a job site, requirement of safety training meetings for each supervisor (foreman and above), requirement for holding tool box/ tailgate safety meetings focused on specific work operations/exposures, emphasis on site managers and supervisors in meetings to maintain a positive attitude towards safety so that workers take safety on the site seriously, requirement of equipment operation/certification training, requirement for conductance of safety inductions for site visitors, requirement for subcontractor workers to attend formal standard safety orientation, requirement for subcontractors to hold regular safety meetings, and monitoring of the effectiveness of health and safety training checking new skills.

4.4.1.3.1.5.Safety Administration and Procedures

This construct consisted of a number of indicators determining the nature and effectiveness of safety administration and procedures provided by management in construction organizations. These included constituent administrative procedures of company's written safety program, documentation of safety work rules for various site operations, review and revision process of work rules, requirement for pre-task safety meetings, discussion of safety at all preconstruction and progress meetings, requirement to perform site layout planning before commencement of work, maintaining first aid facilities on work sites, conductance of emergency response drills, provision of safety bulletin boards, safety signs and posters, system of incentive mechanisms, system of disincentive (penalty) mechanisms, established mechanism to recognize safety accomplishments, maintaining Personal Protective Equipment (PPE) on work sites, procedures to ensure proper use of PPE, requirement to maintain a site hazard register containing hazards, impacts and preventive measures, conducting regular job site safety inspections, conducting routine safety inspection of equipment, maintaining jobsite safety checklists (or similar tools) for inspection, a system to monitor the effectiveness and thoroughness of safety inspection, s system to collect and analyze the results of safety inspections, and a system to ensure that action is taken as a result of the findings of safety inspections.

4.4.1.3.1.6.Accident Investigation and Reporting

This construct consisted of a number of indicators determining the nature and effectiveness of accident investigation and reporting procedures employed by management in construction organizations. These included presence of a procedure to investigate accidents, a system to ensure that appropriate steps be taken to prevent similar accidents in future, requirement to report incidents/ near misses in your reporting system, investigation of near misses to help prevent accidents, keeping of organizational safety records and logs, and a system to effectively use safety records and logs to enhance safety performance.

4.4.1.3.2. Questionnaire

A quantitative research method was chosen to examine the contractor top management attitudes and approaches toward safety, since it was exploratory in nature. Questionnaire survey was used in order to facilitate the collection of information from construction organizations. All indicators (observed variables) were measured through a five-point Likert-type response format. Items, relating to each of the constructs, were used in the form of statements to measure individual constructs under investigation. Participants were asked to endorse the statements using a five-point Likert-type scale (from 1=‘‘strongly disagree’’ to 5=‘‘strongly agree’’). Questionnaire survey is presented in Appendix A.

To achieve acceptable levels of measurement reliability and validity, draft questionnaires were constructed and pretested via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their top management and middle/ project management, all having expertise in or exposure to safety issues. Their input was used to refine the original questionnaire. The questionnaire contained, in its final form, a total of 97 statements about contractor top management attitudes and approaches toward safety. The research targeted top management personnel for general contractors and subcontractors as the survey sample.

Based on all the gathered information, quantitative analysis was performed and the results are discussed in the following section.

4.4.1.4.Data Analysis

The indicators (questionnaire items) in the survey were assumed to reflect the unobserved, underlying construct, with the construct giving rise to (or ‘‘causing’’) the observed measures. For example, constructs such as management commitment & support, and safety communication & decision making are typically viewed as underlying factors that give rise to something that is observed. Accordingly, their indicators tend to be realized as reflective.

4.4.1.4.1. Assessment of Data Reliability and Validity

Prior to data analysis, the reliability and validity of data was assessed using the methodology adopted in similar research (such as Mohamed, 2002). Specifically, three measurement properties need to be examined to ensure that the data has a satisfactory level of reliability and validity (Fornell and Larcker 1981). The first of these is the individual item reliability, where loadings (or simple correlations) of the items on their respective constructs are assessed, using 0.70 as a cutoff point (Fornell and Larcker 1981). Exceeding this value simply implies that less than half of the item’s variance is due to error. Obtained values for items exceeded this threshold, with all loadings in the range of 0.75–0.90, demonstrating the satisfactory level of individual item reliability.

Convergent validity (also referred to as the homogeneity of the construct or composite reliability) is the second measurement property to be examined, and is evaluated by Cronbach's alpha. The Cronbach's alpha obtained for each construct is listed in Table 4.7. All constructs have acceptable convergent validity, as a value of 0.70 is usually accepted as the minimum desired value of the Cronbach's alpha (Litwin 1995).

The third measurement property is the discriminant validity – that is, the extent to which each construct differs from other constructs in the analysis. It is assessed by using the average variance extracted (*Av*), suggested by Fornell and Larcker (1981) (Table 4.7). This measure should be greater than the variance shared between the construct and other constructs in the model (i.e., the squared correlation between two constructs). This can be demonstrated in the correlation matrix, shown in Table 4.8, which includes the correlations between different constructs in the lower left off-diagonal elements of the matrix, and the square root of the average variance extracted (*Av*) calculated for each of the constructs along the diagonal. Having all of the diagonal elements greater than any other corresponding row or column implies adequate discriminant validity.

Having satisfied the three measurement properties, it can be concluded that the constructs are measured with adequate precision.

Table 4.7: Convergent Validity of Independent Constructs

Construct	Cronbach's alpha	Average variance extracted (*Av*)
1. Safety Policy	0.912	0.71
2. Management Commitment and Support	0.875	0.73
3. Safety Communication and Decision Making	0.832	0.69
4. Safety Training and Orientation	0.901	0.67
4. Safety Administration and Procedures	0.854	0.74
5. Accident Investigation and Reporting	0.873	0.78

Table 4.8: Discriminant Validity Analysis

Construct	Construct 1	2	3	4	5	6
1. Safety Policy	**0.84**	-	-	-	-	-
2. Management Commitment and Support	0.09	**0.85**	-	-	-	-
3. Safety Communication and Decision Making	0.13	0.18	**0.83**	-	-	-
4. Safety Training and Orientation	0.15	0.15	0.07	**0.82**	**-**	**-**
5. Safety Administration and Procedures	0.17	0.20	0.13	0.18	**0.86**	**-**
6. Accident Investigation and Reporting	0.19	0.11	0.17	0.12	0.16	**0.88**

4.4.1.4.2. Results and Conclusion

This section presents the results of the survey. Contractor top management attitudes and approaches towards safety were determined by six independent constructs – safety policy, management commitment & support, safety communication & decision making, safety training & orientation, safety administration & procedures, and accident investigation and reporting, Strictly speaking, support was found for the impact of contractor top management safety policy, commitment & support, communication & decision making, training & orientation, administration & procedures, and accident investigation and reporting on the strategic safety improvement in the construction industry.

Descriptive analysis was performed to analyze the results. To assess the extent of impact of each of the measured indicators (survey items) with respect to top management's approach to safety, the mean values of survey responses for each item were used. A mean score of 5 in the final analysis represented best performance on the measured indicator, while a mean score of 1 represented worst performance on the measure under consideration. A mean response score of 4.50 was considered least significant in terms of that particular measure generating (minimal) negative impact on the related construct. In order to distinguish the measures with respect to their extent of impact, the following indicator criticality indexing and zoning criteria was used (Table 4.9).

Table 4.9: Indicator Criticality Indices & Zones

Mean Score Range	Indicator Criticality Index	Indicator Criticality Zone
<=2	6	Major High
2.01-2.50	5	Major Low
2.51 – 3.00	4	Moderate High
3.01-3.50	3	Moderate Low
3.51 – 4.00	2	Minor High
4.01 – 4.50	1	Minor Low
4.51 – 5.00	0	Non-Critical

Tables 4.10-4.15 show the mean response scores and indicator criticality indices for all the items measured in the survey, organized under their respective constructs. The tables have been sorted in descending order of criticality of the indicators measured (based on their mean values).

Table 4.10: Safety Policy Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
I	***<u>Safety Policy</u>***			
1	The company has safety related criterion for subcontractor selection (e.g. past safety records).	2.23	5	Major Low
2	The company has safety related criterion for workers' recruitment (e.g. experience, safety training).	2.32	5	Major Low
3	The company has safety related criterion for managers' & supervisors' recruitment (e.g. experience, safety training).	2.38	5	Major Low
4	The revisions (where relevant) are promptly brought to the attention of all employees.	2.51	4	Moderate High
5	The review arrangement includes feedback from employees at all levels.	2.56	4	Moderate High
6	The safety policy clearly states that decisions on other priorities should give due regard to construction safety requirements.	2.61	4	Moderate High
7	There are effective arrangements for reviewing the health and safety policy at least once a year.	2.61	4	Moderate High
8	The company has a well-written substance abuse program.	3.76	2	Minor High
9	The company has a well-written light-duty, return-to-work policy.	3.96	2	Minor High
10	The policy endeavors to set targets (corporate safety goals) for health and safety performance including a commitment to progressive improvement.	4.01	1	Minor Low
11	The policy identifies key senior personnel for overall coordination and implementation of the policy.	4.11	1	Minor Low
12	The company has a well established disciplinary process for enforcement of safety program/safety plan.	4.11	1	Minor Low
13	The company has a well-written safety field manual.	4.16	1	Minor Low

Table 4.10: Safety Policy Construct (continued)

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
14	As part of company policy, workers are given a booklet containing work rules, responsibilities, and other appropriate information.	4.16	1	Minor Low
15	The company has a well-written personal protective equipment (PPE) policy.	4.16	1	Minor Low
16	The policy is explained to new employees as part of their training and orientation before entry to a work on-site.	4.21	1	Minor Low
17	The company has a well-written policy on accident reporting and investigation.	4.5	1	Minor Low
18	The policy explicitly commits the organization to full compliance with all relevant health and safety legislation.	4.55	0	Non-Critical
19	The company has a well-written safety program manual/ safety plan.	4.8	0	Non-Critical

[1]based on Table 4.9

4.11: Management Commitment & Support Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
II	***<u>Management Commitment & Support</u>***			
20	The number of safety officers delegated on a site depends on the perceived/ evaluated hazards and complexity of the site.	0.79	6	Major High
21	The management emphasizes on having project safety committees.	1.58	6	Major High
22	Safety is a mandatory part of the supervisor's performance evaluation.	1.63	6	Major High
23	There are effective arrangements to collect and review worker feedback on health and safety matters.	1.78	6	Major High
24	The executive management reviews accident reports.	1.83	6	Major High

4.11: Management Commitment & Support Construct (continued)

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
25	The safety officers are delegated the responsibility and authority to suspend work if there are unsafe acts.	1.88	6	Major High
26	The executive management involves itself in promoting safety by giving directions/ motivation.	2.38	5	Major Low
27	The executive management involves itself in enacting incentive schemes to encourage staff and subcontractors to observe safety	2.7	4	Moderate High
28	The executive management involves itself in attending or chairing safety committees.	2.72	4	Moderate High
29	The management clearly emphasizes safety over productivity.	2.86	4	Moderate High
30	The number of safety officers delegated on a site depends on the accident records.	3.22	3	Moderate Low
31	The executive management reviews safety statistics.	3.37	3	Moderate Low
32	The number of safety officers delegated on a site depends on the requirements of the law/ the contract.	3.66	2	Minor High
33	The executive management reviews inspection reports.	3.81	2	Minor High
34	The executive management involves itself in requiring and facilitating regular safety inspection on sites.	3.81	2	Minor High
35	The names and positions with responsibility lines for safety performance management are explicitly identified (such as an organization chart).	3.81	2	Minor High
36	The management sets corporate safety goals.	4.01	1	Minor Low
37	The management always keeps someone in charge of updating health and safety including changes to regulations, new codes of practice, newly identified hazards, and new work practices.	4.16	1	Minor Low

[1]based on Table 4.9

Table 4.12: Safety Communication & Decision Making Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
III	***Safety Communication & Decision Making***			
38	Management strongly emphasizes that safety problems be openly discussed between workers and supervisors.	1.73	6	Major High
39	Management strongly emphasizes that workers be involved in site safety decisions.	1.83	6	Major High
40	As per management directives, a formal behavior observation program exists on work sites.	2.72	4	Moderate High
41	Management strongly encourages workers to raise safety concerns with their supervisors.	2.91	4	Moderate High
42	Management emphasizes that workers be involved in preparation of site safety plans.	2.96	4	Moderate High
43	Management strongly emphasizes that subcontractors/ subcontractor safety rep/ subcontractor staff be involved in site safety decisions.	3.21	3	Moderate Low
44	Management communicates lessons from accidents to workers in order to improve safety performance.	3.26	3	Moderate Low
45	As per management directives, site managers and supervisors are required to engage themselves in regular safety talks with operatives.	3.26	3	Moderate Low

[1]based on Table 4.9

Table 4.13: Safety Training & Orientation Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
IV	***<u>Safety Training & Orientation</u>***			
46	The safety program requires subcontractors to hold regular safety meetings.	1.88	6	Major High
47	The effectiveness of health and safety training is monitored by the company by checking new skills.	1.93	6	Major High
48	Management strongly emphasizes on site managers and supervisors in meetings to maintain a positive attitude towards safety so that workers take safety on the site seriously.	2.43	5	Major Low
49	The safety program requires all subcontract workers to attend a formal standard safety orientation.	2.77	4	Moderate High
50	The health and safety training program/ plan exists at the managerial level.	2.87	4	Moderate High
51	The safety program requires holding tool box/ tailgate safety meetings focused on specific work operations/exposures.	2.87	4	Moderate High
52	The safety program requires conducting safety inductions for site visitors.	3.12	3	Moderate Low
53	The health and safety training program/ plan exists at the supervisory level.	3.32	3	Moderate Low
54	Safety training is always a line or compulsory item within the budget.	3.51	2	Minor High
55	The health and safety training program/ plan exists at the workforce level.	3.61	2	Minor High
56	The safety program requires conducting site safety orientation for every person new to the job site.	3.71	2	Minor High
57	The safety program requires safety training meetings for each supervisor (foreman and above).	4.16	1	Minor Low
58	The company has a well-documented health and safety training program/ plan	4.16	1	Minor Low
59	The safety program requires equipment operation/certification training.	4.75	0	Non-Critical

[1]based on Table 4.9

Table 4.14: Safety Administration & Procedures Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
V	***Safety Administration & Procedures***			
60	The company has an established system to recognize safety accomplishments (such as award given out on a regular basis with recognition given for good safety performance.	1.58	6	60
61	Any non-compliance to wearing appropriate PPE is required by the management to be investigated.	1.63	6	61
62	Management motivates workers to work safely by providing incentives/ awards/ recognitions for good safety performance (e.g. monetary incentives).	1.93	6	62
63	The work rules are regularly updated.	2.18	5	63
64	There are appropriate arrangements to monitor the effectiveness and thoroughness of safety inspection.	2.23	5	64
65	There are appropriate arrangements to collect and analyze the results of safety inspections.	2.28	5	65
66	There are appropriate arrangements to ensure that action is taken as a result of the findings of safety inspections.	2.62	4	66
67	The safety program requires having pre-task meetings before executing an activity.	2.67	4	67
68	The safety program requires performing site layout planning before start of work.	2.72	4	68
69	The management discusses safety at all preconstruction and progress meetings.	2.82	4	69
70	The company's written safety program addresses safety communications procedures.	3.27	3	70
71	The company's written safety program addresses safety risk identification and management procedures.	3.27	3	71
72	The company's written safety program addresses safety planning procedures.	3.27	3	72

Table 4.14: Safety Administration & Procedures Construct (continued)

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
73	Management disciplines workers to work safely by imposing disciplinary action (e.g. penalties) for safety non-performance.	3.27	3	73
74	The safety program requires conducting emergency response drills.	3.32	3	74
75	The company's written safety program addresses physical controls and rules.	3.38	3	75
76	The company's written safety program addresses safety organization and responsibilities.	3.42	3	76
77	The company's written safety program addresses safety implementation, monitoring and control procedures.	3.42	3	77
78	The company's written safety program addresses safety training and awareness procedures.	3.56	2	78
79	The company's written safety program addresses safe work procedures.	3.61	2	79
80	Safety bulletin boards are provided and located so that every employee will see them during working days.	3.66	2	80
81	The safety program requires maintaining a site hazard register containing hazards, impacts and preventive measures.	3.71	2	81
82	The company's written safety program addresses safety reporting procedures.	3.76	2	82
83	Safety signs and posters are prominently displayed on work sites.	3.81	2	83
84	The company maintains jobsite safety checklists (or similar tools) for inspection.	3.86	2	84
85	The company's written safety program addresses accident and emergency response mechanisms.	3.91	2	85
86	The safety program requires conducting regular job site safety inspections/ audits.	3.97	2	86

Table 4.14: Safety Administration & Procedures Construct (continued)

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
87	The company has documented safety work rules/ procedures for all site operations performed by the company (such as excavation works, trenching works, high rise work etc.).	4.01	1	87
88	Site safety inspections are required to include routine safety inspection of equipment (e.g., scaffold, ladders, fire extinguishers, etc.).	4.11	1	88
89	There are established procedures to ensure the proper use of PPE as well as its training and inspection.	4.31	1	89
90	The company maintains PPE facilities on worksites.	4.44	1	90
91	The company maintains continuous supply of first aid facilities on work sites.	4.5	1	91

[1]based on Table 4.9

Table 4.15: Accident Investigation & Reporting Construct

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
VI	***Accident Investigation & Reporting***			
92	The company has a system to effectively use safety records and logs for enhancing safety performance.	2.37	5	Major Low
93	Management requires investigating near misses to help prevent accidents.	2.64	4	Moderate High
94	Management requires reporting incidents/ near misses in the company's reporting system.	2.85	4	Moderate High
95	After each accident, appropriate steps are taken to prevent similar accidents in future.	2.96	4	Moderate High

Table 4.15: Accident Investigation & Reporting Construct (continued)

S. No.	Top Management Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
96	The company always investigates accidents.	2.98	4	Moderate High
97	Management requires keeping safety records and logs (such as in a database that logs injuries on past projects).	3.9	2	Minor High

[1]based on Table 4.9

After analyzing Tables 4.10-4.15, the major critical contractor top management safety non-performance indicators (with criticality indices = 5 or 6), ranked in descending order of criticality (based on mean response score), are shown in Table 4.16. Table 4.16 also provides mean response rate, associated constructs, and indicator criticality ranking for these key safety non-performance indicators. The first column in Table 4.16 provides the serial number of these indicators as given in Tables 4.10-4.15.

Table 4.16: Key Top Management Safety Non-Performance Indicators – All Constructs

S. No.	Top Management Safety Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
20	The number of safety officers delegated on a site depends on the perceived/ evaluated hazards and complexity of the site.	0.79	Management Commitment & Support	1
21	The management emphasizes on having project safety committees.	1.58	Management Commitment & Support	2
60	The company has an established system to recognize safety accomplishments (such as award given out on a regular basis with recognition given for good safety performance.	1.58	Safety Administration & Procedures	3

Table 4.16: Key Top Management Safety Non-Performance Indicators – All Constructs (continued)

S. No.	Top Management Safety Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
22	Safety is a mandatory part of the supervisor's performance evaluation.	1.63	Management Commitment & Support	4
61	Any non-compliance to wearing appropriate PPE is required by the management to be investigated.	1.63	Safety Administration & Procedures	5
38	Management strongly emphasizes that safety problems be openly discussed between workers and supervisors.	1.73	Safety Communication & Decision Making	6
23	There are effective arrangements to collect and review worker feedback on health and safety matters.	1.78	Management Commitment & Support	7
24	The executive management reviews accident reports.	1.83	Management Commitment & Support	8
39	Management strongly emphasizes that workers be involved in site safety decisions.	1.83	Safety Communication & Decision Making	9
25	The safety officers are delegated the responsibility and authority to suspend work if there are unsafe acts.	1.88	Management Commitment & Support	10
46	The safety program requires subcontractors to hold regular safety meetings.	1.88	Safety Training & Orientation	11
47	The effectiveness of health and safety training is monitored by the company by checking new skills.	1.93	Safety Training & Orientation	12
62	Management motivates workers to work safely by providing incentives/ awards/ recognitions for good safety performance (e.g. monetary incentives).	1.93	Safety Administration & Procedures	13

Table 4.16: Key Top Management Safety Non-Performance Indicators – All Constructs (continued)

S. No.	Top Management Safety Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
63	The work rules are regularly updated.	2.18	Safety Administration & Procedures	14
1	The company has safety related criterion for subcontractor selection (e.g. past safety records).	2.23	Safety Policy	15
64	There are appropriate arrangements to monitor the effectiveness and thoroughness of safety inspection.	2.23	Safety Administration & Procedures	16
65	There are appropriate arrangements to collect and analyze the results of safety inspections.	2.28	Safety Administration & Procedures	17
2	The company has safety related criterion for workers' recruitment (e.g. experience, safety training).	2.32	Safety Policy	18
92	The company has a system to effectively use safety records and logs for enhancing safety performance.	2.37	Accident Investigation & Reporting	19
3	The company has safety related criterion for managers' & supervisors' recruitment (e.g. experience, safety training).	2.38	Safety Policy	20
26	The executive management involves itself in promoting safety by giving directions/ motivation.	2.38	Management Commitment & Support	21
48	Management strongly emphasizes on site managers and supervisors in meetings to maintain a positive attitude towards safety so that workers take safety on the site seriously.	2.43	Safety Training & Orientation	22

Further assessment of Tables 4.10-4.15 – to identify construct criticality ranking (based on a value of weighted mean response score for each construct) – results in Table 4.17. Table 4.17 has been arranged in descending order of construct criticality, and also provide construct criticality ranking and criticality zone.

Table 4.17: Construct Criticality Ranking & Zone

Construct	Weighted Mean Response Score (Scale 1-5)	Criticality Ranking	Criticality Zone
Safety Communication & Decision making	2.74	1	Moderate High
Management Commitment & Support	2.78	2	Moderate High
Accident Investigation & Reporting	2.95	3	Moderate High
Safety Training & Orientation	3.22	4	Moderate Low
Safety Administration & Procedures	3.27	5	Moderate Low
Safety Policy	3.56	6	Minor High

The major contractor top management safety non-performance indicators (with an indicator criticality index = 5 or 6) constitute 22 out of a total of 97 indicators i.e. 22.68%. The moderate contractor top management safety non-performance indicators (with an indicator criticality index = 3 or 4) constitute 36 out of a total of 97 indicators i.e. 37.11%. Minor contractor top management safety non-performance indicators (with an indicator criticality index = 1 or 2) constitute 36 out of a total of 97 indicators i.e. 37.11%. The remaining 3 indicators (3.09%) are not perceived by the industry as negative aspects of contractor top management safety performance.

Safety communication and decision making, management commitment and support, accident investigation and reporting, safety training and orientation are all important components of a strategic total safety environment. Lack of performance of top management on these areas undoubtedly indicate that contractor top management is not performing well in terms of achieving strategic safety improvement in the construction industry. Hence it can be concluded that the strategies, approaches, methods and operations adopted by contractor top management are not helping as they should in strategically improving safety in the construction industry.

4.4.2. Survey 2: Assessment of current safety attitudes and approaches of supervisors and foremen in the construction industry

4.4.2.1.Survey Description

The construction supervisor/ foreman is typically the key person of contact for workers in the field on a construction project. He is responsible for the direct daily supervision of activities and his key task is to see that all work elements are fitted together in the right sequence and at the right time. He plays an important role in organizing and managing productivity, quality, and safety outcomes. In regards to safety, it is critical for a supervisor to be equipped with the training, knowledge, and skills to not only carry out the safety management practices but to instill safety in the workers' attitudes and behaviors. The role supervisors play in promoting safety cannot be overemphasized. Supervisory commitment is a central element of construction safety; a supervisor with a positive safety attitude is vital in maintaining a safe work environment. Many key elements dictate a safety conscious working environment, which the supervisor initiate and instill. The attitude, interaction and communication of supervisors with workers in terms of their commitment, support and motivation can have a positive (or negative) influence on workers' perceptions, attitudes, competence, and behaviors towards safety. Furthermore, supervisor is an important link between the workforce and management. As referenced earlier, Neal et al. (2000) identified two distinct management approaches to safety: 1) safety compliance, which involves requiring adherence to safety procedures and carrying out work in a safe manner, and 2) safety participation, which involves supporting and helping workers, promoting the safety program within the workplace, demonstrating initiatives, and putting efforts into safety for improving the safety performance. Based on management preference, the supervisors' attitude and approach towards safety can have a significant impact on workers' safety preferences and attitudes because the supervisor acts as a bridge between workers and management. For instance, the supervisor's attitude to safety generates as well as reinforces employee perceptions about what gets rewarded, supported and expected in a particular setting. Hence a supervisor's attitude towards safety must be taken into account while addressing the safety performance of a construction organization. This dimension of research is significant not only to understand supervisors' role in strategically improving safety in the construction industry but also to determine how construction supervisors impact safety performance and hence the worker safety behavior through their management attitudes and practices.

For the purpose of this study, the evaluation of safety attitude of supervisors in the industry was done by conducting a safety attitude survey in construction organizations that examined the supervisory approach and practices as a predictive tool to demonstrate how safety is operational on sites within the construction organizations in the industry. A survey was designed and distributed to contractor and subcontractor supervisory staff (including foremen and line managers) for assessing the overall safety attitudes on sites by taking into account their safety commitment and support, safety training and orientation approach, disciplinary approach towards safety, safety communication, authority and decision making, and approach towards maintaining a safe work environment and a positive worker safety attitude. Conclusions drawn from this research will strengthen or weaken the argument that the supervisors in construction organizations in the U.S. are generally focused towards safety compliance rather than safety participation.

From the perspective of the overall objective of this dissertation, the underlying objective of this research study on construction supervisors was to collect and analyze data on supervisor attitudes and practices, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous safety improvement.

4.4.2.2.Methodology

Structured surveys were conducted to achieve the study objectives. The methodology of survey development and administration was the same as discussed in section 3.2.2.3.

The following sections illustrate the major findings of the research conducted for the key question at hand: Are the strategies, approaches, and methods currently employed by supervisors helping in strategically improving safety in the construction industry?

4.4.2.3.Data Collection

On the basis of literature review, seven key constructs (factors) were identified along with a number of associated indicators (observable items in terms of survey questions) to analyze supervisor attitudes and approaches with respect to strategically improving safety in construction organizations. The constructs are described in the following sub-section.

4.4.2.3.1. Constructs

The following seven constructs (factors) were used to analyze the various facets of supervisor attitudes and approaches towards safety.

4.4.2.3.1.1. Training and Orientation

Safety training is a major component of jobsite safety. Even skilled and experienced workers need a firm-specific safety and health orientation and training. Safety training can modify worker safe behavior; the workers can understand the work potential hazard such that they can prevent it (Hallowell and Gambatese, 2009). Supervisors play a significant role in the training and orientation process of workers. This support comes in the form of explaining safety operations and rules to workers, holding regular safety meetings, coaching workers, providing job-specific safety training, and holding toolbox safety meetings focused on specific work operations and exposures. The greater the level of supervisory commitment toward worker safety training and orientation, the better would be the site safety performance. This construct consisted of various indicators determining the nature and extent of support provided by supervisors in terms of worker safety training and orientation.

4.4.2.3.1.2. Safety Administration

This construct consisted of a number of indicators determining the nature and effectiveness of safety administration as provided & facilitated by supervisors in construction organizations. Aspects of administering safety in the workplace include taking unsafe tools out of production, reporting and investigating accidents, maintaining a continuous supply of first aid facilities on site, establishing inspection teams for hazard analysis, inspecting work, and correcting unsafe conditions and acts.

4.4.2.3.1.3.Maintaining Discipline

The aim in maintaining discipline in the workplace is to produce a functional working environment that will maximize productivity and minimize risks. Sites where discipline in the workplace has been adequately maintained are more likely to provide a high level of safety performance ((Hallowell and Gambatese, 2009). This construct consisted of a number of indicators determining the nature and effectiveness of the discipline maintained by supervisors in construction organizations. Aspects of maintaining discipline in the workplace include issuing warnings to workers, recommending promotion or demotion to a worker, granting pay raises to workers, requiring workers to report any unsafe behaviors by a fellow worker, enforcing the use of personal protective equipment whenever needed, and conducting emergency response drills.

4.4.2.3.1.4.Safety Communication

Supervisors are expected to use a variety of formal and informal means of communication to promote safety in the workplace (Baxendale and Jones 2000). Simon and Piquard (1991) suggests that both management communication and employee feedback are critical for suggesting safety improvements and reporting near misses as well as unsafe conditions and practices. This construct consisted of a number of indicators determining the nature and effectiveness of the safety communication by supervisors in construction organizations. Aspects of supervisor-level communication include authorizing timely maintenance/ repairs of equipment, making informed suggestions to improve safety, discussing safety issues with the top management, recommending changes in safety policies and procedures if needed, improving work procedures through worker involvement, keeping an open-door policy on safety issues, encouraging feedback from workers on safety issues, and communicating workers' safety concerns to top management.

4.4.2.3.1.5.Safety Commitment and Support

Supervisory commitment and support are central to maintaining a safe work environment. Supervisor's role has to go beyond organizing and providing safety administration and work rules. Supervisory commitment and involvement in safety is a factor of key importance for a satisfactory safety level. Langford et al. (2000) found that when employees believe that the management cares about their personal safety, they are more willing to cooperate to improve safety performance. Having demonstrated supervisory commitment and support to safety develops trust and fosters closer ties among workers, and between workers and supervisors. This construct consisted of a number of indicators determining the nature and extent of supervisory commitment and support towards safety in construction organizations. Aspects of supervisory commitment and support include emphasizing a no-blame approach to highlight unsafe work behavior, reminding workers to work safely, facilitating in maintaining a safe workplace environment, emphasizing on workers to help fellow workers and to maintain good working relationships, ensuring that the workload is reasonably balanced among workers, emphasizing on workers to achieve high levels of safety performance, play an active role in identifying site hazards, report accidents, incidents, and potentially hazardous situations, maintaining a positive attitude towards safety during meetings, allowing and encouraging workers to act decisively if they find any unsafe situation, emphasizing on workers to reflect on safety practice, contribute to accident investigations and job safety analysis, participating actively in developing / reviewing health and safety procedures, ensuring good emergency preparedness among workers, providing safe equipment, keeping safety as a primary consideration when planning, and identifying potential risks and consequences prior to execution.

4.4.2.3.1.6.Maintaining a Positive Attitude towards Safety

A positive attitude towards safety refers to the degree of emphasis, encouragement and support provided by supervisors to their workers in terms of identifying, reporting, solving, advocating, and prioritizing safety concerns and issues. Having a positive attitude towards safety by the supervisors demonstrates their unequivocal commitment to safety and hence the desired and approved worker behaviors. Langford et al. (2000) indicate that the more positive the attitude of supervisors is towards safety, the more likely it is that workers will perform safely. This construct consisted of a number of indicators determining the role of supervisors in maintaining a positive attitude towards safety in construction organizations. Aspects of maintaining a positive safety attitude by supervisors include engaging oneself in regular safety talks, discussing safety problems openly with workers, welcoming the reporting of safety hazards, resolving safety issues, never advocating working around safety procedures to meet deadlines, valuing ideas from workers about improving safety, providing the help, authority, information and resources workers need to behave safely, having safety as one's top priority, and always informing workers of safety concerns and issues.

4.4.2.3.1.7.Motivating

Motivating refers to promoting a feeling of belonging, job satisfaction, care for personal problems, and recognition among workers in order to strengthen the workers' positive attitude towards safety. Motivation by supervisors strengthens relationships and fosters closer ties between the supervisors and workers. It also improves the general morale and worker attitude towards safety. Motivation may include promoting job satisfaction among workers, creating a feeling of belonging among workers, demonstrating a commitment of help and care for workers' personal problems, guaranteeing job security, and recommending recognitions and benefits. Langford et al. (2000) indicate that the more motivated the workers are, the more likely it is that they will perform safely. This construct consisted of a number of indicators determining the role of supervisors in motivating workers in construction organizations. Aspects of motivation by supervisors include promoting a feeling of belonging among workers, promoting job satisfaction, caring for workers' personal problems, guaranteeing job security, and recommending recognitions and benefits.

4.4.2.3.2. Questionnaire

A quantitative research method was chosen to examine the supervisor attitudes and approaches toward safety, since it was exploratory in nature. Questionnaire survey was used in order to facilitate the collection of information from construction organizations. All indicators (observed variables) were measured through a five-point Likert-type response format. Items, relating to each of the constructs, were used in the form of statements to measure individual constructs under investigation. Participants were asked to endorse the statements using a five-point Likert-type scale (from 1=‘‘strongly disagree’’ to 5=‘‘strongly agree’’). Questionnaire survey is presented in Appendix B.

To achieve acceptable levels of measurement reliability and validity, draft questionnaires were constructed and pretested via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their supervisors and foremen, all having expertise in or exposure to safety issues. Their input was used to refine the original questionnaire. The questionnaire contained, in its final form, a total of 68 statements about supervisor attitudes and approaches toward safety. The research targeted supervisory level personnel (including supervisors, foremen, line managers) from general contractor and subcontractor organizations as the survey sample.

Based on all the gathered information, descriptive analysis was performed and the results are discussed in the following section.

4.4.2.4.Data Analysis

The indicators (questionnaire items) in the survey were assumed to reflect the unobserved, underlying construct, with the construct giving rise to (or ‘‘causing’’) the observed measures. For example, constructs such as safety commitment & support, and safety communication are typically viewed as underlying factors that give rise to something that is observed. Accordingly, their indicators tend to be realized as reflective.

4.4.2.4.1. Assessment of Data Reliability and Validity

Prior to data analysis, three measurement properties need to be examined to ensure that the data has a satisfactory level of reliability and validity (Fornell and Larcker 1981). The first of these is the individual item reliability, where loadings (or simple correlations) of the items on their respective constructs are assessed, using 0.70 as a cutoff point (Fornell and Larcker 1981). Exceeding this value simply implies that less than half of the item’s variance is due to error. Obtained values for items exceeded this threshold, with all loadings in the range of 0.80–0.95, demonstrating the satisfactory level of individual item reliability.

Convergent validity (also referred to as the homogeneity of the construct or composite reliability) is the second measurement property to be examined, and is evaluated by Cronbach's alpha. The Cronbach's alpha obtained for each construct is listed in Table 4.18. All constructs have acceptable convergent validity, as a value of 0.70 is usually accepted as the minimum desired value of the Cronbach's alpha (Litwin 1995).

The third measurement property is the discriminant validity – that is, the extent to which each construct differs from other constructs in the analysis. It is assessed by using the average variance extracted (***Av***), suggested by Fornell and Larcker (1981) (Table 4.18). This measure should be greater than the variance shared between the construct and other constructs in the model (i.e., the squared correlation between two constructs). This can be demonstrated in the correlation matrix, shown in Table 4.19, which includes the correlations between different constructs in the lower left off-diagonal elements of the matrix, and the square root of the average variance extracted (***Av***) calculated for each of the constructs along the diagonal. Having all of the diagonal elements greater than any other corresponding row or column implies adequate discriminant validity.

Having satisfied the three measurement properties, it can be concluded that the constructs are measured with adequate precision.

Table 4.18: Convergent Validity of Independent Constructs

Construct	Cronbach's alpha	Average variance extracted (*Av*)
1. Safety Training & Orientation	0.873	0.75
2. Safety Administration	0.892	0.70
3. Maintaining Discipline	0.912	0.73
4. Safety Communication	0.905	0.69
5. Safety Commitment and Support	0.868	0.77
6. Maintaining a Positive Attitude towards Safety	0.887	0.74
7. Motivating Workers	0.845	0.68

Table 4.19: Discriminant Validity Analysis

	Construct						
Construct	1	2	3	4	5	6	7
1. Safety Training & Orientation	**0.87**	-	-	-	-	-	-
2. Safety Administration	0.09	**0.84**	-	-	-	-	-
3. Maintaining Discipline	0.13	0.18	**0.85**	-	-	-	-
4. Safety Communication	0.15	0.15	0.07	**0.83**	**-**	**-**	**-**
5. Safety Commitment and Support	0.17	0.20	0.13	0.18	**0.88**	**-**	**-**
6. Maintaining a Positive Attitude towards Safety	0.19	0.11	0.17	0.12	0.16	**0.86**	**-**
7. Motivating Workers	0.21	0.17	0.09	0.13	0.11	0.19	**0.82**

4.4.2.4.2. Results and Conclusion

This section presents the results of the survey. Supervisor attitudes and approaches towards safety were determined by seven independent constructs— safety training & orientation, safety administration, maintaining discipline, safety communication, safety commitment & support, maintaining a positive attitude towards safety, and motivating workers. Strictly speaking, support was found for the impact of above aspects of supervisory support on the strategic safety improvement in the construction industry.

Descriptive analysis was performed to analyze the results. To assess the extent of impact of each of the measured indicators (survey items) with respect to supervisory approach to safety, the mean values of survey responses for each item were used. A mean score of 5 in the final analysis represented best performance on the measured indicator, while a mean score of 1 represented worst performance on the measure under consideration. A mean response score of 4.50 was considered least significant in terms of that particular measure generating (minimal) negative impact on the related construct. In order to distinguish the measures with respect to their extent of impact, the following indicator criticality indexing and zoning criteria was used (Table 4.20).

Table 4.20: Indicator Criticality Indices & Zones

Mean Score Range	Indicator Criticality Index	Indicator Criticality Zone
<=2	6	Major High
2.01-2.50	5	Major Low
2.51 – 3.00	4	Moderate High
3.01-3.50	3	Moderate Low
3.51 – 4.00	2	Minor High
4.01 – 4.50	1	Minor Low
4.51 – 5.00	0	Non-Critical

Tables 4.21-4.27 show the mean response scores and indicator criticality indices for all the items measured in the survey, organized under their respective constructs. The tables have been sorted in descending order of criticality of the indicators measured (based on their mean values).

Table 4.21: Safety Training and Orientation Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
I	***Safety Training and Orientation***			
1	I am responsible to provide job-specific safety training	3.03	3	Moderate Low
2	I am responsible to hold tool box/ tailgate safety meetings focused on specific work operations/exposures	3.19	3	Moderate Low
3	I am responsible to hold safety meetings	3.41	3	Moderate Low
4	I am responsible to coach workers	3.51	2	Minor High
5	I am responsible to explain safety operations/ rules to workers	3.62	2	Minor High
6	I am responsible to orient new workers	3.98	2	Minor High

[1]based on Table 4.20

Table 4.22: Safety Administration Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
II	***Safety Administration***			
7	I am responsible to establish inspection teams for hazard analysis	2.66	4	Moderate High
8	I am responsible to investigate accidents	3.07	3	Moderate Low
9	I am responsible to correct unsafe conditions	3.19	3	Moderate Low
10	I am responsible to take unsafe tools out of production	3.22	3	Moderate Low
11	I am responsible to correct unsafe acts	3.28	3	Moderate Low
12	I am responsible to report all incidents/ near misses	2.48	5	Major Low
13	I am responsible to authorize regular maintenance or repair of equipment	3.77	2	Minor High

Table 4.22: Safety Administration Construct (continued)

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
14	I am responsible to report all accidents	3.81	2	Minor High
15	I am responsible to maintain first aid facilities	3.93	2	Minor High
16	I am responsible to conduct (safety) inspection of my own division of work	3.95	2	Minor High
17	I am responsible to send the injured or sick workers for medical attention	4.01	1	Minor Low

[1]based on Table 4.20

Table 4.23: Discipline Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
III	***<u>Maintaining Discipline</u>***			
18	I am responsible to require workers to report any malpractice by a fellow worker	2.12	5	Major Low
19	I am responsible to conduct emergency response drills	3.73	2	Minor High
20	I am responsible to report a worker for unsafe acts	2.73	4	Moderate High
21	I am responsible to discharge a worker's duties	2.95	4	Moderate High
22	I am responsible to recommend promotion or demotion to a worker	3.37	3	Moderate Low
23	I am responsible to issue warnings to workers in case of unsafe acts	3.67	2	Minor High
24	I am responsible to enforce the use of personal protective equipment whenever necessary	4.05	1	Minor Low

[1]based on Table 4.20

Table 4.24: Safety Communication Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
IV	***<u>Safety Communication</u>***			
25	I am responsible to recommend changes in safety policy	2.57	4	Moderate High
26	I involve/ consult workers in preparation of task safety plan	2.42	5	Major Low
27	I encourage feedback from workers on safety issues	2.46	5	Major Low
28	I am responsible to improve safe work procedures through worker involvement	2.93	4	Moderate High
29	I keep an open-door policy on safety issues	2.93	4	Moderate High
30	I take responsibility to communicate workers' safety concerns to management	3.38	3	Moderate Low
31	I take responsibility to make suggestions to improve safety	3.54	2	Minor High
32	I take responsibility to discuss safety problems with the management	3.62	2	Minor High

[1]based on Table 4.20

Table 4.25: Safety Commitment & Support Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
V	***<u>Safety Commitment & Support</u>***			
33	I emphasize on workers to contribute to job safety analysis	2.58	4	Moderate High
34	I ensure good preparedness for emergency among workers	2.61	4	Moderate High
35	I allow workers to act decisively if they find any situation contrary to safe conditions on site	1.95	6	Major High
36	I participate actively in developing / reviewing health and safety procedures	2.68	4	Moderate High

Table 4.25: Safety Commitment & Support Construct (continued)

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
37	I take responsibility to ensure that the workload is reasonably balanced among workers	2.70	4	Moderate High
38	I emphasize on workers to contribute to accident investigations	2.74	4	Moderate High
39	I continuously emphasize on workers that safety rules should not be broken, even when worker believes it affects the production	2.75	4	Moderate High
40	I emphasize on a no-blame approach to highlight unsafe work behavior	2.50	5	Major Low
41	I emphasize on workers to achieve high levels of safety performance	2.81	4	Moderate High
42	I take responsibility to provide right equipment to the workers so that they can do the job safely	2.84	4	Moderate High
43	I take responsibility to detect potential hazards as part of the planning exercise	2.84	4	Moderate High
44	I often remind workers to work safely	2.93	4	Moderate High
45	I emphasize on workers that everyone has the responsibility to reflect on safety practice	2.93	4	Moderate High
46	I emphasize on workers that safety is the number one priority while working	2.98	4	Moderate High
47	I keep safety as a primary consideration when planning	3.02	3	Moderate Low
48	I take responsibility to never allow working with defective equipment	3.03	3	Moderate Low
49	I emphasize on workers to report accidents, incidents, and potentially hazardous situations	3.06	3	Moderate Low
50	I emphasize on workers to offer help to fellow workers when needed to perform the job safely	2.38	5	Major Low
51	I emphasize on workers to maintain a good relationship with fellow workers	2.40	5	Major Low
52	I emphasize on workers to play an active role in identifying site hazards	3.18	3	Moderate Low

Table 4.25: Safety Commitment & Support Construct (continued)

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
53	I endeavor to maintain a positive attitude towards safety during meetings so that workers take safety on the site seriously	3.20	3	Moderate Low
54	I take responsibility to identify potential risks & consequences prior to execution	3.22	3	Moderate Low
55	I emphasize on workers to ensure that individuals are not working by themselves under risky or hazardous conditions	2.76	4	Moderate High
56	I react strongly against workers who break health and safety procedures / instructions / rules.	3.56	2	Minor High

[1]based on Table 4.20

Table 4.26: Maintaining a Positive Attitude Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
VI	***<u>Maintaining a Positive Attitude</u>***			
57	I engage myself in regular safety talks (discuss safety problems openly with workers and supervisors)	2.97	4	Moderate High
58	I never advocate working around safety procedures to meet deadlines	3.20	3	Moderate Low
59	I welcome reporting safety hazards/incidents	3.74	2	Minor High
60	I gather ideas from workers about improving safety when significant changes to work practices are suggested	2.46	5	Major Low
61	I provide the help, authority, information & resources workers need to behave safely	3.78	2	Minor High
62	I always inform workers of safety concerns and issues.	3.89	2	Minor High
63	I take responsibility to solve safety problems	3.92	2	Minor High

[1]based on Table 4.20

Table 4.27: Motivating Construct

S. No.	Supervisor Safety Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
VII	***Motivating***			
64	I take responsibility for assuring job security of workers under my belt	1.70	6	Major High
65	I am responsible for recommending recognition/ reward for good safety performance	1.97	6	Major High
66	I take responsibility for helping and caring for workers' personal problems	2.31	5	Major Low
67	I take responsibility for creating feeling of belonging among workers	2.91	4	Moderate High
68	I take responsibility for promoting job satisfaction among workers	3.52	2	Minor High

[1]based on Table 4.20

After analyzing Tables 4.21-4.27, the critical supervisor safety non-performance indicators (with criticality indices = 3), ranked in descending order of criticality (based on mean response score), are shown in Table 4.28. Table 4.28 also provides mean response rate, associated constructs, and indicator criticality ranking for these key non-performance indicators. The first column in Table 4.28 provides the serial number of these indicators as given in Tables 4.21-4.27.

Table 4.28: Key Supervisor Safety Non-Performance Indicators – All Constructs

S. No.	Supervisor Safety Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
64	I take responsibility for assuring job security of workers under my belt	1.70	Motivating	1
35	I allow workers to act decisively if they find any situation contrary to safe conditions on site	1.95	Safety Commitment and Support	2
65	I am responsible for recommending recognition/ reward for good safety performance	1.97	Motivating	3
18	I am responsible to require workers to report any malpractice by a fellow worker	2.12	Discipline	4
66	I take responsibility for helping and caring for workers' personal problems	2.31	Motivating	5
50	I emphasize on workers to offer help to fellow workers when needed to perform the job safely	2.38	Safety Commitment and Support	6
51	I emphasize on workers to maintain a good relationship with fellow workers	2.40	Safety Commitment and Support	7
26	I involve/ consult workers in preparation of task safety plan	2.42	Safety Communication	8
27	I encourage feedback from workers on safety issues	2.46	Safety Communication	9
60	I gather ideas from workers about improving safety when significant changes to working practices are suggested	2.46	Maintaining a Positive Attitude	10
12	I am responsible to report all incidents/ near misses	2.48	Safety Administration	11
40	I emphasize on a no-blame approach to highlight unsafe work behavior	2.50	Safety Commitment and Support	12

Further assessment of Tables 4.21-4.27 – to identify construct criticality ranking (based on a value of weighted mean response score for each construct) – results in Table 4.29. Table 4.29 has been arranged in descending order of construct criticality, and also provide construct criticality ranking and criticality zone.

Table 4.29: Construct Criticality Ranking & Zone

Construct	Weighted Mean Response Score (Scale 1-5)	Criticality Ranking	Criticality Zone
Motivating Workers	2.48	1	Major Low
Safety Commitment and Support	2.82	2	Moderate High
Safety Communication	2.98	3	Moderate High
Maintaining Discipline	3.23	4	Moderate Low
Safety Administration	3.40	5	Moderate Low
Maintaining a Positive Attitude towards Safety	3.42	6	Moderate Low
Safety Training & Orientation	3.46	7	Moderate Low

The major supervisor safety non-performance indicators (with an indicator criticality index = 5 or 6) constitute 12 out of a total of 68 indicators i.e. 17.64%. The moderate supervisor safety non-performance indicators (with an indicator criticality index = 3 or 4) constitute 37 out of a total of 68 indicators i.e. 54.41%. Minor supervisor safety non-performance indicators (with an indicator criticality index = 1 or 2) constitute 19 out of a total of 68 indicators i.e. 27.94%.

Worker motivation, safety commitment and support, safety communication, maintaining a positive attitude towards safety, and safety training and orientation are all important components of a strategic total safety environment. Lack of performance of supervisors on these areas undoubtedly indicates that supervisors and foremen not performing well in terms of achieving strategic safety improvement in the construction industry. Hence it can be concluded that the strategies, approaches, and methods adopted by supervisors are not helping as they should in strategically improving safety in the construction industry.

4.4.3. Survey 3: Analysis of the criticism on OSHA with respect to its lack of success in acting as a catalyst to incorporate total safety in a construction organizations

4.4.3.1.Survey Description

In the United States, all construction safety is legislated by the Occupational Safety & Health Administration (OSHA), a federal agency that is part of the U.S. Department of Labor, which was created by the Congress under the Occupational Safety and Health Act in 1970. OSHA has claimed credible statistics over the years showing that, since its implementation by Congress has had a beneficial influence on US industries by significantly reducing workplace accidents. Under the Occupational Safety and Health Act of 1970, Occupational Safety and Health Administration's role is to "assure safe and healthful working conditions for every working man and woman in the Nation; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health". (Ballard and Howell, 1998)

OSHA develops a series of specific minimum construction standards, and policies for enforcing the standards to assist in the safety management process. The construction industry standards (29 CFR 1926) are not guidelines, but legal requirements that define the minimum protections construction organizations must provide their workforce on the job site. OSHA periodically develops and publishes amendments to standards that through time may have become outdated or are in need of additional clarification. It is vitally important that all OSHA regulations and requirements be strictly followed or the construction organization could be subject to fines and penalties; worker's compensations premium may increase; and this may have a negative impact on the company's ability to prosper in the marketplace. For that very reason, construction organizations typically employ a safety manager or a competent person, while larger companies may employ outside consultants to develop and enforce safety management procedures. Outside safety consultants can become a valuable member of the team by visiting the jobsite to provide detailed safety advice, training, and other related safety knowledge as required. Whatever the solution, an effective construction safety and health program must be a core element of a construction company's management strategy, with the ultimate goal to prevent workplace accidents and reduce occupational injuries.

Credible statistics reveal that OSHA has had a beneficial influence on the US construction industry in terms of reducing workplace accidents and occupational injuries. Undoubtedly, OSHA has played a pivotal role in the development of a safer work environment over the years. Nevertheless, the agency still has received substantial criticism from construction organizations for a number of reasons. Even though the number of workplace accidents and casualties has dropped down drastically in the construction industry ever since OSHA regulations have been implemented, construction firms have viewed OSHA's regulations and standards in a negative light as well. This is despite the numerous attempts by the agency to promote training, consultation, and outreach services. “To assure safe and healthful working conditions for every working man and woman in the Nation” – the failed mission statement of OSHA is a constant reminder of some inherent inefficacies in the strategic operations of the organization.

One of the more common arguments against OSHA is that its heavy fines and burdensome regulations deliver an overbearing and unwanted presence that greatly restricts an organization’s ability to develop as well as compete. On one hand, the overburdening regulations place a heavy impediment on organizations by forcing increased operational fees and the costs associated to retrofit equipment rather than investing on improving the processes and culture for achieving long-term (strategic) safety objectives. Companies that invest but are still unable to meet the regulations owing to their own deficiencies (which may not necessarily be because of their poor attitude towards safety) may encounter increased accidents, strict OSHA fines, worker’s compensation premium increases, and will ultimately have a negative impact on the company’s ability to succeed in the global marketplace. On the other hand, although the ultimate goal is safety, the overbearing fines/ penalties have actually put a negative strain on the never ending battle to make construction companies and their jobsites safer. The heavy penalties compel organizations to concentrate on avoiding penalties and trying to “stay away” from OSHA, especially if they are not at par with the standards issued by OSHA, rather than investing in maintaining the ultimate goal of safe workplaces. This has created an adversarial relationship between the industry and OSHA in general and has not allowed OSHA to keep up its role as safety advisors in order to facilitate in strategically improving safety in the industry.

There are other arguments as well. Observers have questioned whether the reported drop in injury rates could be all attributed to OSHA's enforcement activities. Another argument is that the agency is not actively participating in the necessary research to view and incorporate safety as an industrial development process, and hence their regulations do not support implementing safety as a total management process. Most critics further charge that the OSHA's inspection and penalty approach is an inappropriate and ineffective way to ensure workplace safety, and OSHA has been accused of being more devoted to the numbers of inspections rather than to actual safety and has been criticized for taking decades to develop new regulations.

This research was aimed to identify the aspects of OSHA 's regulations, methods and approach that seem to provide a negative influx towards developing a strategic safety culture in a construction organization, as well as identify the reasons that lead to such a criticism to OSHA's mode of operation. Conclusions drawn from this research will strengthen or weaken the argument that OSHA's current regulations and implementation methods compel construction organizations to invest in following procedures rather than to invest in achieving long- term strategic safety objectives. The survey will also diagnose what the construction contracting organizations feel that OSHA is not putting in the needed effort in the research and development process of safety and is mainly acting as a watch dog rather than an organization providing mechanisms for achieving total safety goals.

From the perspective of the overall objective of this dissertation, the underlying objective of this research study on OSHA was to collect and analyze data on OSHA criticism, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety management framework in the construction industry to achieve continuous safety improvement.

4.4.3.2.Methodology

Since no prior formal information (such as journal papers, conference papers, books, published articles, etc.) as to the effectiveness of OSHA in the construction industry was available, this research on OSHA criticism was conducted in two steps:

1. Unstructured interviews. These open-ended discussions were done via face-to-face meetings and telephonic communication with selected professionals including short-listed experts representing contractors and sub-contractors. The interviewed audience included top managers, middle/ project managers and construction superintendents. A total of 27 interviews were conducted and the findings compiled. The primary objective of these interviews was to determine the key information parameters to be used in developing a structured survey in the next step.
2. Structured surveys. The results of the open-ended interviews were utilized to draft a structured questionnaire to assess OSHA's non-performance issues. The methodology of survey development and administration was the same as discussed in section 3.2.2.3.

The following sections illustrate the major findings of the research conducted for the key question at hand: Are the strategies, approaches, methods and operations adopted by OSHA helping in strategically improving safety in the construction industry? Firstly, the key findings of the unstructured interviews are discussed. This is followed by the results of the structured surveys.

4.4.3.3.Unstructured Interviews

The key criticisms on OSHA's performance as indicated by the interviewees are discussed below.

Criticism 1: OSHA's methodology of implementing and enforcing its policies has flaws.

OSHA has lately come under wide criticism concerning its methodology of implementing and enforcing its policies and the high cost incriminated with the compliance of such, as compared to the rate of reduced work related injuries and deaths. Most interviewees emphasized that OSHA's policies can be termed as routine as opposed to drawing attention to prevention or taming the root causes of the hazards. They advocated for the focus to shift to preventing the root cause, developing channels for reporting accidents and conducting detailed scrutiny of the root cause, and rectification to completion. It was further suggested that the channels of communication should be defined as such to give room for reporting 'near misses'.

Criticism 2: OSHA disregards the productivity side of doing business

A key issue and concern in regards to OSHA has been how OSHA policies affect work productivity. Interviewees claimed that work places have suffered from the enforcement of OSHA standards in terms of low productivity levels. The argument is that OSHA should be enforcing standards that provide safe as well as productive work environment for everyone by developing better procedures. The criticism towards OSHA is for the failure to create and advance such procedures to be used in work places that will not reduce production. As suggested by one respondent and endorsed by many: "OSHA only concentrates on safety side of doing business and totally disregards the productivity side. More productive procedures can be safer as well. However, OSHA completely disregards this aspect and makes its own recommendations without putting in the research needed to drive a high-productivity safety culture."

Criticism 3: OSHA is unreasonably slow in incorporating new safety guidelines

Many companies critic OSHA because it is slow to set or improve on new safety guidelines. OSHA has been accused of emphasizing too much time and resources on inspections when it should be emphasizing that time and resource on developing new regulations. A few comments from interviewees in relation to this aspect were as follows: "If OSHA is there to protect us then why does it take so long to enforce new rules such as the one for crane lifting? Why the 30 years old lifting regulation is still in effect? OSHA needs to understand that enforcing a good safety on crane is highly recommended, to protect workers and surrounding area." "We understand the governmental requirements and processes that have to be followed but OSHA needs to work faster on implementing rules and regulations." "OSHA needs to start preventing accidents before they happen, and they need to reinforce some of the old safety rules and regulations." "It is not a good way of handling business; OSHA seems to take forever to implement new safety guidelines." "OSHA needs to revise guidelines as technology changes". Commenting on OSHA's permissible exposure limit (PEL) on noise, one representative of a mechanical subcontractor stated: "If OSHA promises us to be safe, how come every other country updated their system on PEL and OSHA keeps it at the same rate? Personally, I know a couple of people who used to work on the railroad and lost their hearing at an early age." One suggestion given by a number of interviewees was that "the government needs to let OSHA to act as a separate agency. The government process will always slow down

OSHA on implementing new rules and regulations. It’s time for OSHA to realize that it needs to be an agency that does not depend on the government and lawyers to approve rules, at least on important safety issues.”

Criticism 4: OSHA’s regulations do not comprehensively cover major safety and health issues

Unsafe practices that are not listed in the known hazards in the OSHA act are grouped under 'general duty'. This is basically a loophole that ends up limiting numerous unsafe practices into being classified into general duty. “OSHA lays emphasis to big known hazards while ignoring others that are apparently more hazardous. For instance, a law on large explosions and major accidents is most visible in the Act, while job-related health issues account for more than 80 percent of all problems at the work place.”

Criticism 5: OSHA’s standards are dated

Unfortunately, many professionals complain about OSHA’s standards being outdated. There are many OSHA standards that are decades old. For example, the standards for derricks and hoists are based on the 1943 edition of ANSI B30.2 and the standard for woodworking machinery dates to the 1954 edition of ANSI O 1.1. This is a strong example indicating how some areas of OSHA have seemed to be untouched. For years, construction industry experts have complained about this problem of old and outdated standards. These outdated standards can drastically affect workers’ safety and put harm into their way. The best resolution to this problem is to have the standards looked over and replaced with proper up-to-date standards.

Criticism 6: OSHA's penalty mechanism is ineffective and has created serious doubts as to the agency's sense of purpose

A major criticism on OSHA has been that, over the years, a pro safety entity has been becoming a pro revenue collector. To justify this opinion, respondents referred to data depicting that in 1976, 95 percent of OSHA citations were classified as "non-serious" (in terms of monetary value) while in 2008, 70 percent of citations were classified as "serious". An accusation by most is that OSHA has stepped up its role as a revenue collector for the federal government. As per the interviewees, this is evident from the range of OSHA's maximum allowable penalties which have been increased many-fold over recent years, and $900 million in additional revenues are expected over the next five years . "OSHA is now implementing expensive citations to the companies that can range from 7,000 dollars to 70,000 for a repetitive infraction." While this increased penalty has been justified by OSHA personnel as being an effective means of safety enforcement, this has been viewed by the industry, in general, as a move of OSHA from being a safety proactive agency to a revenue generation agency for the government. This accusation is backed by the fact that every governmental entity in the country has to meet certain objective and economical growth goals so that their funds are not lowered significantly for the next year. An associated accusation is that OSHA does not respect companies, in general, as fair and safe employers and mostly acts as any other law enforcer with penalties as their weapons.

The other side of the picture was depicted by a number of interviewees by reflecting that although the maximum penalty for violating an OSHA safety standard is $70,000, willfully violating an OSHA safety standard has no extra penalty unless there has been a death of an employee because of that particular violation. In that respect, OSHA's penalty mechanism is ineffective, particularly criminal penalties. OSHA is only able to pursue a criminal penalty when a willful violation of an OSHA standard results in the death of a worker. The maximum penalty is a misdemeanor with a maximum of 6-months in jail. Many condemn this practice and believe the time should fit the crime. One of the respondents, who worked for a government entity as a general contractor, summed up this part of the debate perfectly when he said, "If you improperly import an exotic bird, you can go to jail for two years. If you deal in counterfeit money, you're looking at 20 years. But if you gamble with the lives of your employees and one of them is killed, you risk only six months in jail." This is evident by a recent example, which was often cited by a number of respondents. On Nov. 28, 2008, a Wal-Mart Employee was trampled to death when opening the doors for the day after Thanksgiving Day sale. Wal-Mart was only fined $7,000 for not having proper crowd control management. A recent report by OSHA shows that, in 2010, 1,832 fatalities where investigated and the average penalties for all convictions came out to $11,543. Besides the fact that one cannot set a price on a person's life, a measly $11,543 is actually an insult to the deceased and their family members. In fact, in OSHA's 40 years of existence, they have managed to secure only 12 criminal convictions of jail time, which, as stated before, is not harsh enough for the crime committed.

Criticism 7: Interpretation of regulations is at most times vague

Unlike other government agencies such as the Food and Drug Administration which hire scientists and leaders in the field the agencies enforce, OSHA is run mostly by lawyers and senior businessmen. OSHA has come under considerable criticism with the issue of imposing fines based on the assertion that rules can be interpreted in different ways and since lawyers and businessman are not as knowledgeable in construction field as construction workers, contractors, subcontractors, etc., their interpretation is usually much different then what actual experience and work environment has taught. A related example cited by a number of respondents was for the year 2003 in the states of Massachusetts and Florida where OSHA issued several citations for scaffolding. The violation was for statute 29 CFR 1926 250(b) (5); the prohibition against leaving more materials on scaffolding than necessary for immediate operations. The inspector who read and issued the citations was taking the rule to mean literally and since he either had no or little experience in the construction field, believed that these companies where creating a hazardous work environment. It is a common practice in the construction field to leave materials on the scaffold for many reasons. When laying bricks, workers would want to have a supply of bricks with them so that they can place the guard rail for safety. Having to climb up and down continuously to bring bricks up will leave the guard rail unattached which increases the chances of a workers falling off of the scaffold. It is also a regular practice to leave materials and tools on the scaffold overnight or between shifts as this allows the boards to stay in place if a severe gust of wind was to hit the scaffold. Without the materials on the scaffold, the boards would fly off and could possibly hurt a worker below. In the same light, having the extra weight of the material while workers are on the scaffold can help in the stability of the scaffold and that of the board placement. Without the extra weight on the boards, as a worker moves around, the lack of weight and the constant vibration will cause the board to shift, which may result in a serious accident. There are other reasons why extra material on the scaffolds are a good idea and a safe practice although one could understand the possible problems of having too much materials on the scaffold with workers.

Criticism 8: OSHA does not participate enough in research and development

OSHA is strongly critiqued for its lack of participation in the research and development of new and improved safety procedures, methods, and standards. There is a constant growth in the working environment and, therefore, a need for continuous study and exploration to find new and improved methods for building and sustaining a safe working environment for all.

Criticism 9: OSHA regulations are ambiguous at times

As per the respondents, OSHA has some regulations that employers do not understand or do not know how to make effective. For instance, one respondent commented on one OSHA regulation by saying: “OSHA states that plastic gas cans can be used on manufacturing work sites, but not on construction sites, even if they have been approved by local fire marshals. As weird as it seems, OSHA contradicts what an experienced fire marshal allows. This shows a clear contradiction between the two entities and would not be beneficial for the industry.”

Moreover, safety violations are often grouped into the agency’s “general duty” clause, allowing inspectors to cite companies for unsafe practices that are not specifically regulated. This means that there is broad aspect of violations that does not have specific instructions or guidelines of how to prevent them. This can upset some business owners who get slapped with fines that they don’t know anything about. This lack of guidelines makes business owners lose money while, at the same time, lose production. One general contractor argued that OSHA regulations “are generally broad but necessary in the workplaces." He also stated that while regulations are not thoroughly clear, they are essential in maintaining a safe and healthy work atmosphere. He and many other respondents argued for clearer regulations.

Criticism 10: OSHA is not proactive

OSHA has been criticized for not being proactive in their approach but rather being reactive to circumstances. A good argument was given by a respondent who remarked that "one reason noise hasn't gotten the attention it deserves is because it's not immediately life-threatening like many other construction hazards. But loss of one's hearing destroys a worker's quality of life and creates safety hazards on the job. Without OSHA's support, we've had to find other ways to protect people." One common argument given by many respondents was that OSHA does fine for violations, but does not follow through nor does it provide instructions on how to improve existing conditions. This reactive approach by OSHA was evidenced by a number of citations from personal experiences given by many respondents. For instance, an earthwork contractor representative alluded to a jobsite he was working on as a field superintendant. The foundations to a precast parking structure were under way and were in the excavation stage. The backhoe operator hit underground utilities and was nearly electrocuted to death as a result of the strike. OSHA immediately arrived on the scene and scrutinized the workplace. Soon after, a citation was issued and then the OSHA officials were no longer seen on the worksite. Neither did they provide any instructions as to how to improve on the safety of the workplace. This shows that a retaliatory action was taken and then safety was scrutinized with a fine-toothed comb. However, nothing was done to provide assistance/ guidance to the employer to improve on safety.

Another argument posed by a number of respondents was that OSHA should leave a positive impression on contractors, foreman, and all those involved. “OSHA has set up a rulebook. You must follow A, B, C, and D to avoid fines rather than establish a safety culture or mindset.” “Don’t slap me on my hand and simply tell me I did this, show me how I can be better. Show me how my crews can be better.” Most respondents witnessed that they have experienced only few inspections unless involved with a high-priority job. “They are so concerned with documenting violations and snapping photos, versus mitigating safety. So, naturally, contractors and their subs are going to walk the straight and narrow, losing sight of the overall picture of a safe workplace.” “Positive reinforcement is the best method to reach a goal.” “At the end of the day, we’re all trying to make money. So, reward contractors. Treat them like kindergarten children and reward a child with a sticker or piece of candy. Reward the good boys and girls who are safe with a reward such as certificate or documentation that they can present to their insurance companies to lower their premiums or policy rates. Let their safe track record qualify them for specific jobs. Treat it like LEED that has caught like wildfire. In today’s market, who can afford to be unsafe? There is no reason why, if the right incentive is present, anyone can’t behave in a specified manner.”

Opinions were gathered wherein the respondents proposed that insurance companies, contractors (and subcontractors), and OSHA should be involved with setting safety goals. The argument was that it is important to set up long-term objectives that have a reward for the contractor. This would change the attitude from trying to avoid OSHA violations towards showcasing the safety of all employees and operations on work site. This cannot be achieved by merely implementing a reward clause. If this were to be put into effect, it would require public meetings and advertising. An example of an ideal scenario is on a government pre-bid meeting, where an OSHA representative is present to explain the new incentives and reinforce as to how beneficial it can be. Owners could partake in this by informing contractors that "X amount of accident-free days will result in Y amount of added profit."

Criticism 11: OSHA does not improvise with changing conditions

In an interview with a construction project manager, a valid point was made about the affect of economy on the safety of work site. The interviewee stated that he has witnessed how job assurance has caused an increase in safety hazards on the work site. The current economic conditions have become reason for many people to be worried if they have job assurance and has forced them to go to great lengths to make sure they will always have a working position. He also explained how these lengths have come to include putting the employees themselves and/or other employees at risk to get their job done. What is upsetting is that despite the obvious hazard nothing has been done upon OSHA's part to attempt to reverse this affect. The economy has unfortunately influenced the work environment negatively in this way and an organization such as OSHA should be doing something to change this issue into a better solution.

Criticism 12: OSHA has insufficient funds

Respondents criticized that OSHA has insufficient funding from the government, which could pose to be a big problem for OSHA to be able to function in the way that the public would like it to. OSHA's lack of funds has dated back years and is not a recent problem for the association. "OSHA needs to invest more money if they really want to protect the public and the area. They need to staff their offices in a way to make the public feel safe." "Hire enough people and pay them well, to do a better job." "The more money spent in a project the better result will come out of it." "The more OSHA invests on the inspectors the better they will be."

Criticism 13: OSHA Inspections are Devious

A growing concern of businessmen is OSHA sneaking up on workers. OSHA is no stranger to the courtroom; people are and have been angry towards OSHA for the way they operate. "18 state and federal court decisions have been handed down against the agency for violating the Fourth Amendment guarantee against unlawful search and seizure." "This is a direct violation of the constitution; they use sneaky tactics to write more citations instead of spreading efforts to increase safety in the workplace." "There is plenty of evidence that such tactics simply make enforcement all the harder." "If the OSHA inspector and I could work together to make my place safe, it would be good. But if he comes in to get me and fine me, I'm going to hide everything I can from him." "The message should be: let's work together not against each other."

Criticism 14: OSHA does not conduct regular inspections

Most respondents criticized OSHA for not conducting inspections often enough. It was found that companies in certain states had spans of 12 years between OSHA inspections. That's an outrageous length of time between inspections, and that isn't the worst, some reached as long as 22 years between inspections. This obviously puts doubt into the effectiveness of OSHA if there are such long spans between simple inspections, which would probably do a lot of good in helping companies to comply with standards more easily. OSHA only enforcing its standards without properly inspecting them is somewhat contradictory. Simply surprise inspecting every several years without making sure companies are taking the proper approach to the standards set by OSHA via inspections is not proper operating procedures. A common accusation by respondents was that that OSHA takes more into effect about fining and charging companies rather than worrying about having a proper number of inspections. OSHA representatives used to and still do get paid for the fines that they write for companies that disobey or neglect the rules. Lives are at great risks on construction job sites and having more professional inspections by OSHA representatives will greatly reduce the risk of injury or death.

Criticism 15: Some OSHA inspectors lack competence

A common complaint from contractor representatives against OSHA inspectors was that some OSHA inspectors arriving at construction sites are transfers from other OSHA areas who do not have any construction experience/ exposure. "The hazards in construction are much different than those in a plant. That's one thing that OSHA should consider with very much attention because if they hire someone without construction knowledge and/ or experience, they should not expect that person to know what needs to be done and how it is done correctly." Apparently, OSHA does not always send qualified inspectors to jobsites. "Anytime an OSHA inspector comes into one of the facilities where we are working as mechanical contractors, it is probably the first time they have ever seen such a large commercial building project at work. The OSHA inspector usually doesn't know where to start. In every case, the inspector will invariably find a guard off, or some other minor, readily apparent violation on the site, but will pass by our process equipment which, if it failed, could blow up the facility." This comment surely tells that people in charge of maintaining safety for a certain project do not even know how the project participants (various contractors and subcontractors) work. These inspectors have to be prepared in what they would encounter. "On repeated occasions I have seen the results of OSHA inspections where the compliance officers were plainly wrong in what they were advocating. The issues included misinterpretation of injury data, inappropriate use of quantitative methods, and dubious recommendations for task improvement. I am referring to individuals who are *not* ergonomics professionals, rather inspectors who have taken a few classes." "Many of the OSHA field staff have gone their own direction and have cited companies in ways that are inappropriate and contrary to the understandings of our discussions in preparing that document, when the OSHA personnel in Washington D.C. provided sensible interpretations of their intent. I have observed OSHA field staff insist on actions that have wasted money without helping any workers."

Criticism 16: OSHA has adversarial relation with construction industry

OSHA's presence on work sites is mostly viewed as an overbearing organization that merely means that safety fines and documented violations are soon to follow. Advice given from contractors is to avoid OSHA "like the plague." Although this is the industry attitude towards OSHA, it is not a far stretch of what actually happens once OSHA steps foot on a jobsite. There are reasons as to why OSHA has been deemed as such a burden on jobsites and has an adversarial relationship with the industry. Industry experts had to say the following in relation to OSHA's relationship with the construction industry. "The relations between OSHA and construction industry have been unnecessarily adversarial, and I have observed little or no trust, even in companies that have outstanding safety efforts." "I find it sobering when I end up advising companies to set up a two-track approach — one for worker safety and the other to satisfy OSHA. This is because OSHA is always focusing on the small picture rather than the strategic one. OSHA has created regulations and mandates those would ensure safety, but merely treat them like a checklist. This is no way to run the nation's workplace safety process." "Congress enacted OSHA in 1970 explicitly to serve as police, not as educators or advisors. This probably was appropriate then, but not now, and has led to glaringly unsuitable policies." "I was told by an inspector regarding a company with an admirable ergonomics program, "I know [this company] has a good ergonomics program; my job is to poke holes in it." OSHA should instead have held a press conference to highlight a success story, but they chose to cite the company for some minor shortcomings."

Criticism 17: OSHA's policies are overly demanding

Data collected revealed that most construction industry individuals strive to meet or exceed OSHA's strict policies because they know that an OSHA compliance officer has the authority to enter, at reasonable times, any site, location, or facility where the work is taking place without any prior notice to the contractor, and if the OSHA officer has an issue with the construction site, he/she has the authority to stop work, give a citation and penalize the job depending on the issue in the field. This is fine as long as the policies are reasonable as well as implementable. However, the industry had a different opinion. "Enforcing the stringent mandated requirements, for example, something as simple as the basic housekeeping takes such an effort from all the subcontractors and the enforcement from the general contractor on a daily basis that it becomes unreasonable at times." "Enforcing one-hundred percent tie off has been the toughest challenge in my career, whether it is on fork lifts, scissor lifts or any equipment higher than five feet. At often times, it's just not practically possible. At other times, there really is no way to completely tie off and still maintain a reasonable rate of production." "Being in the construction industry for over 20 years, I have witnessed that OSHA officers usually don't show up on jobsites unless there's a complaint, and once they do arrive, they often ask for implausible resolutions. The actions or steps that they deem required to be taken as remediating measures are, at often times, unreasonable in terms of time, money and effort required as against their perceived safety benefits, and, at other times, practically impossible to implement. Needless to say that the often impracticable OSHA rules are usually made by white collar well-suited officers sitting in plush seats somewhere in Washington D.C. who do not have any faintest idea about the real time challenges on construction work sites." "OSHA regulations stop us from using another method of safety that might be more worthwhile as well as safe for the completion of the project. Instead OSHA sticks by their own recommendations and regulations without compromising to an idea that makes more sense."

"OSHA is helping as well as hurting. It helps by having standards to make a job site safer but all job sites are unique, so it's hard to apply certain regulations tom all sites. Some regulations are a bit excessive just like their fines." "OSHA has overreacted by jamming every conceivable danger, however remote, into a code that must be the world's most boring reading. With appropriate illustrations, an OSHA manual seems to instruct farmers how to avoid slipping on cow dung. In order for people to follow directions or codes they must be reasonable." "OSHA inspectors, at often times, are so over-demanding that meeting their expectations would require turning an 8-hour job site into a 16-hour job-site resulting in an eventual collapse of the company. Safety is of prime importance and must be implemented to the full extent. However, the implementation requirements must not be demanding to an extent that they become unreasonable and overburden. OSHA needs to be more realistic in its approach and the inspectors need to be well-trained as well as well-equipped with appropriate, reasonable and implementable safety suggestions specific to construction sites."

Criticism 18: OSHA has an enforcement/ governance focus rather than a strategic improvement focus

Interviews revealed that most respondents were of the opinion that OSHA's tact on the nation's work environment is to strongly enforce their standards when the association's calling should be to make sure there are laws protecting employees from health and safety hazard incidents in which the corporation is at fault, the development and research of better procedures for employees and employers to use, and the assessing of certain health & safety issues at hand in order to devise proper solutions. As respondents suggested, this "may be related to their lack of funding and improper methods". "The use of enforcing standards strictly has become the main goal to the agency when it should be sub-category of core principles built within." "OSHA worries too much on their inspections and not on implementing new ideas". "Much of the debate about OSHA regulations and enforcement policies revolves around the cost of regulations and enforcement, versus the actual benefit in reduced worker injury, illness and death." A former OSHA employee who has worked for OSHA almost since it came into existence was not happy with the direction of OSHA and its focus and stated "I heard classic bureaucratic answers: more regulations, more staff, more money, more & more & more, etc. i.e. more government is the solution to everything. Thousands of years of civilized earth history prove that more government creates more problems than it solves. This agency is not exactly doing what is needed to make the workplace safer; more government will only lead to a “police state”. OSHA does not promote being creative and thinking outside the box; rather they make an army of mindless soldiers with their citation book in hand.”

Majority of the survey respondents were of the opinion that OSHA has not been focusing on strategic safety improvement. “There has been much controversy and criticism surrounding OSHA and their regulations. Where did a safety agency go wrong? The agency has gotten its fair share of criticism just as it got started for mandating that businesses furnish safety equipment and have safety training for employees. This may sound fine, but imagine how these new regulations that were and still are enforceable by law cost these businesses. I would even go as far as saying some small businesses had to shut down. Some ask the question: is OSHA helping or hurting? Some are convinced that OSHA is more concerned with the amount of citations and fines than the actual reduction to workplace illnesses and accidents. Instead of OSHA fining these companies with citations, it would make more sense to use that money for long term safety investment. There are companies that are more careless than others and need to be showed somehow that they need to better their safety environments. By working with the companies and not against them, they can prevent many small businesses from going bankrupt and at the same time improve worker safety.” ““OSHA operates against the employer instead of with. I feel as if they really want to catch you doing something that deserves a citation.”

“OSHA’s methods restrict construction organizations to invest in following procedures rather than to invest in achieving long- term safety objectives. By having regulations and standards that are legally enforceable by fines and, in some cases, jail time, the agency cuts profits for companies to grow and improve safety programs. A workable solution to this dilemma is that OSHA, instead of being what it has been viewed as, becomes a helping hand assisting companies to improve their safety performance. Possibly, even reinvesting some or all of the money collected from fines into helping the companies improve their safety performance with grants for safety equipment or incentives for the companies to compete and improve. Another suggestion is to not employ inspectors but rather employ safety personnel whose objective would be to assist companies to improve on their safety performance.

"The amount of money companies spend on citations is a lost cause; imagine half of that was put to better use. It would be a great feat to improve on safety with that money instead of giving the money to the government. Keeping it mandatory for the company to spend the citation amount on training employees on safety, and purchasing safer and/or newer equipment would strategically improve the industry level of safety performance over time."

"If you give a man a fish, you feed him for a day; show him how to catch a fish, you feed him for a lifetime. The same rule applies for keeping construction companies safe. Rather than inspecting whether or not a contractor is up to par with OSHA regulations, it would be much better and strategic to show the contractor how to be safe."

A few respondents even suggested that OSHA's role as a safety enforcement agency would become unnecessary if workers' attitudes and behaviors can be improved by long-term safety strategic safety investments by companies. "Workers need to be responsible on the job site at all times. I never want to see one of "my guys" get hurt. I also believe they want to be safe. The trick to "No OSHA" is finding or developing good employees.

If your employees are good, and you have a structured and an organized company with a strategic concern to safety, OSHA would be completely unnecessary."

Criticism 19: OSHA's penalty system restricts strategic safety improvement

Although the ultimate goal is safety, the survey respondents strongly suggested that overbearing fines and penalties have actually put a negative strain on the never ending battle to make construction companies and their jobsites safer. The argument given was that rather than maintaining the ultimate goal of safe workplaces, OSHA has concentrated on defining penalties and issuing fines to companies and individuals who are not up to par with the standards issued by OSHA. The respondents were of the opinion that this is a problem that needs to be addressed by reverting to the fundamentals of what an organization like OSHA is to accomplish. Some of the opinions collected were as follows: "Congress did not create OSHA to pursue unsafe practices, but to ensure that every American on a construction site would not be worried whether or not he or she would make it home that day. Safety is what they should sought for, and not issuing fines." "OSHA might make a regulation that one company might break and instead of correcting it they are just fined heavily for it. The money that was used to pay off the fine could have been used to better whatever problem was there in the first place." "In the instance that a company is fined for misuse of the way they were handling the equipment for $500, that money could have easily gone towards something such as training for the workers on how to properly and safely use the equipment. Instead, OSHA feels that fining these small companies will teach them a lesson and that if they do not want to get fined again they will correct it and properly train their employees. In my opinion, this is an inappropriate approach. Many companies go out of business just because of all the fines that they have to pay off. All of the money that goes into paying for these fines can be used to better the working conditions of the job site and make it safer and easier to follow the regulations placed by OSHA." "Monies spent on the process of issuing fines can be channeled towards improving the safety mindset of contractors. If the contractor is going to be charged, encourage an improvement in safety, such as investing for reinforcing safety on the site and/ or investing in additional safety training of the employees. This would direct the potential fine towards everyone's benefit. The contractor will still have to pay, but the benefits would be self-collecting."

"If a company were to have an incident in which an employee was injured due to the company's inability to keep up with OSHA's standards, the company would most likely be heavily fined for it. How would that help the company to keep the problem from occurring again? Say, the incident occurred because the company couldn't afford proper safety equipment. OSHA's standard to add a heavy fine on top of whatever would be needed to be paid to the employee due to the incident would definitely not help the company to obtain the proper equipment that they needed in the first place. So, now the company needs to attempt to recover from the incident for one, pay the fines from OSHA for two, and endeavor on a mission to come up with the equipment that they were supposed to have prior to the whole incident for three."

"Even though OSHA may give an employer a couple of warnings before a fine is issued, I don't agree with the magnitude of the fines. Most construction companies are struggling as it is and certainly do not need unexpected fines sealing their doom. I strongly believe that the penalty mechanism from OSHA is not beneficial in any way and should be replaced by an alternate system providing incentive as well as support to contractors for performing safely. This would not only instill a care and concern of employers not to their employees but would also develop respect and adherence to OSHA policies because the contractors would believe that OSHA is an agency working with them and for them, and not against them."

In an interview with a senior representative from OSHA wherein the respondent was asked as to why OSHA chooses to fine companies for breaking an OSHA regulation instead of making them use that money to better their safety performance, the response was, "In my opinion, OSHA does not want to complicate things too much by making these construction companies responsible with using money that would have gone towards a fine to better the regulation that they should have been followed in the first place". A senior project manager from a general contractor made the following assertion in relation to the agency's approach too imposing fines: "OSHA has been around for a long time and they know what to expect from the companies and job sites that they visit. They know how things are supposed to be and to them there is no other way to do them. Making a mistake in the workplace or not complying with a safety regulation is out of the question. Although there might be many requests for making use of a certain amount of citation money to better their conditions, OSHA will most likely never implement something like that because it is just easier to fine people and make them pay with cash for their faults. Many companies deserve it but that money can easily go towards bettering the workplace and correcting whatever problem they were being fined for in the first place". These responses clearly suggest that OSHA is not inclined to work with the companies to strategically improve their safety performance, but is rather more concerned about seeking violations and imposing fines. Working with the companies would not only make OSHA easier to comply with but would also keep companies from going out of business by throwing away all of their money in fines because of mistakes.

According to the OSHA compliance guidance center, there are many people that call in to complain about OSHA's standards. One of the employees there was asked what he has to say about OSHA's fines and the criticism it receives. He answered with this, "I get many phone calls about people criticizing the fines that they receive and wanting to get rid of the fines and use that money to correct whatever they did or did not do in accordance to OSHA standards but the matter of the fact is they did not follow safety procedure and because of that they were fined. Many people call in and complain about how some of the OSHA standards are too strict and some people even call in to complain that the standards are not strict enough, the fact still remains that they need to abide by these rules despite what they might think and disagree with OSHA".

Key Conclusions from Interviews

In conclusion, OSHA's mission of assuring, for every working man and woman in the Nation, a safe and healthy work environment has sunk into the hearts of many as a very noble idea. It is actually in agreement with most players in the field of public health like Institute of Medicine (IOM). However, it is the adherence to the stated policies that players have taken issues with. From the fact that the top management is headed by politically appointed individuals with little knowledge on safety, to the methodology of the execution of the laws and enforcement which often are irksome to individuals and businesses, this exposes loopholes in their operations which makes the construction organizations to solely concentrate on following the immediate set regulations to avoid law implications, as opposed to adhering to policies that would avert such occurrences in the long term. Disaster avoidance is a major concern to construction organizations. To reach that level of safety would call for structures to be put in place to investigate the root cause, eliminate the potential of such in the future, sustain the control of the danger by keeping a look out on the symptoms of looming illness or injury and carrying out routine preventive maintenance on the equipment. To ensure that it remains relevant, therefore, OSHA must review its policies to give allowance to statements that curb long term dangers so as to place itself as the platform of safety and health protection among construction organizations. OSHA needs to adopt a no-blame approach in order to strategically improve safety at the industry level. OSHA was not created to torment contractors by appearing on jobsites without notice to see how many violations can be seen on a jobsite, but to ensure safety in the long-term. The argument is not to bash OSHA or to blatantly state that the organization is not poorly executed, but to merely suggest improving the methods that should drive construction companies and their employees to be safer. The goal of a contractor is not to execute a single project successfully and safely, but to operate as a business successfully and safely. OSHA has been at the forefront of safety, but change needs to occur to ensure that their methods do not divert contractors from being a safe operating enterprise.

OSHA is in no way trying to harm companies but without a strategic system of safety improvement to go along with the fault identification system currently in place, companies would be paying less attention to set and improve long-term safety objectives, but rather would be more inclined to hide facts from OSHA's inspectors so as not to get fined. Although the fining system OSHA implemented isn't the worst one, it obviously fails to strategically improve safety at the industry level. OSHA needs to cooperate with companies and replace their fining system with one that makes employers invest in long term safety objectives by providing incentives as well as support.

4.4.3.4.Structured Survey

On the basis of unstructured interviews as discussed in section 4.4.3.3, three key constructs (factors) were identified along with a number of associated indicators (observable items in terms of survey statements) to structurally analyze OSHA's non-performance issues with respect to strategically improving safety in the construction industry. The constructs are discussed below.

4.4.3.4.1. Constructs

The following key constructs (factors) were used to analyze the various facets of OSHA's performance as perceived by the construction industry professionals.

4.4.3.4.1.1.Regulations & Standards

The regulations provided by OSHA have been criticized for a number of reasons. These include, in particular, their lack of clarity, impractical nature, implementation difficulty, lack of acceptance by employers and employees, infrequent updating, non-conformance with new technology, susceptibility to manipulation, overloaded and overly strict nature, unreasonable requirement of work hours and capital, high cost-to-benefit ratio, and negative impact on worker productivity, worker morale, and construction business in general. This part of the survey collected structured industry opinions on the above aspects collectively determining the perceived effectiveness of OSHA's regulations in the industry.

4.4.3.4.1.2.Enforcement Methods

OSHA's safety enforcement methods have been criticized for being ineffective, reactive, aimed at rectifying single events rather than improve the industry, insensitive to the needs & limitations of employers, oriented entirely towards inspection and penalties rather than proactively preventing accidents and identifying problems before they occur, and not focused towards positive safety reinforcement. This part of the survey collected structured industry opinions on the above aspects collectively determining the perceived effectiveness of OSHA's safety enforcement methods in the industry.

4.4.3.4.1.3.Vision & Approach

OSHA has been criticized for adopting, in general, an inappropriate vision towards strategic safety improvement in the industry. In this respect, OSHA has been criticized by the industry, in particular, for lack of active participating in necessary research activities that would have allowed incorporating safety as an industrial development process, lack of concentration on positive safety reinforcement, inappropriate focus on the apparent causes of accident (such as worker behavior) and not on the underlying factors leading to those accidents (such as organizational leadership, work pressure, communication, etc.), failure to adopt a proactive approach for developing long term safety measures, failure to develop standards effective towards developing a total safety culture in a construction organization, and failure to develop methods that would have allowed organizations to: invest in strategic safety rather than investing in following day-to-day procedures, invest in improving processes rather than investing in products, and invest in long term rather than short term. This part of the survey collected structured industry opinions on the above aspects collectively determining the perceived effectiveness of OSHA's vision for strategic and continuous safety improvement in the industry.

4.4.3.4.2. Questionnaire

A quantitative research method was chosen to examine the criticism on OSHA, since it was exploratory in nature. Questionnaire survey was used in order to facilitate the collection of information from construction organizations. All attributes (factors) were measured through a five-point Likert-type response format. Items, relating to each of the attributes, were used in the form of statements to measure individual attributes under investigation. Participants were asked to endorse the statements using a five-point Likert-type scale (from 1=''strongly disagree'' to 5=''strongly agree''). Questionnaire survey is presented in Appendix D.

To achieve acceptable levels of measurement reliability and validity, draft questionnaires were constructed and pretested via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their top management and middle/ project management, all having expertise in or exposure to safety issues. Their input was used to refine the original questionnaire. The questionnaire contained, in its final form, a total of 44 statements about OSHA's safety performance for the four attributes diagnosed. Most of the statements presented in the scale were negatively worded, as recommended in the measurement literature (Pedhazur and Schmelkin 1991). The research targeted top management, senior project managers, safety managers/officers and construction superintendents working for general contractors and subcontractors as the survey sample.

Based on all the gathered information, descriptive analysis was performed and the results are discussed in the following section.

4.4.3.4.3. Data Analysis

The indicators (questionnaire items) in the survey were assumed to reflect the unobserved, underlying construct, with the construct giving rise to (or ‘‘causing’’) the observed measures. For example, constructs such as vision and advising support are typically viewed as underlying factors that give rise to something that is observed. Accordingly, their indicators tend to be realized as reflective.

4.4.3.4.3.1. Assessment of Data Reliability and Validity

Prior to data analysis, three measurement properties need to be examined to ensure that the data has a satisfactory level of reliability and validity (Fornell and Larcker 1981). The first of these is the individual item reliability, where loadings (or simple correlations) of the items on their respective constructs are assessed, using 0.70 as a cutoff point (Fornell and Larcker 1981). Exceeding this value simply implies that less than half of the item’s variance is due to error. Obtained values for items exceeded this threshold, with all loadings in the range of 0.80–0.95, demonstrating the satisfactory level of individual item reliability.

Convergent validity (also referred to as the homogeneity of the construct or composite reliability) is the second measurement property to be examined, and is evaluated by Cronbach’s alpha. The Cronbach’s alpha obtained for each construct is listed in Table 4.30. All constructs have acceptable convergent validity, as a value of 0.70 is usually accepted as the minimum desired value of the Cronbach’s alpha (Litwin 1995).

The third measurement property is the discriminant validity – that is, the extent to which each construct differs from other constructs in the analysis. It is assessed by using the average variance extracted (*Av*), suggested by Fornell and Larcker (1981) (Table 4.30). This measure should be greater than the variance shared between the construct and other constructs in the model (i.e., the squared correlation between two constructs). This can be demonstrated in the correlation matrix, shown in Table 4.31, which includes the correlations between different constructs in the lower left off-diagonal elements of the matrix, and the square root of the average variance extracted (*Av*) calculated for each of the constructs along the diagonal. Having all of the diagonal elements greater than any other corresponding row or column implies adequate discriminant validity.

Having satisfied the three measurement properties, it can be concluded that the constructs are measured with adequate precision.

Table 4.30: Convergent Validity of Independent Constructs

Construct	Cronbach's alpha	Average variance extracted (*Av*)
1. Regulations & Policies	0.897	0.69
2. Enforcement Methods	0.818	0.65
3. Advising Support	0.844	0.67
4. Vision and Approach	0.921	0.72

Table 4.31: Discriminant Validity Analysis

Construct	Construct			
	1	2	3	4
1. Regulations & Policies	**0.83**	-	-	-
2. Enforcement Methods	0.12	**0.81**	-	-
3. Advising Support	0.17	0.08	**0.82**	-
4. Vision and Approach	0.13	0.09	0.19	**0.85**

4.4.3.4.3.2.Results

This section presents the results of the survey. OSHA's performance was determined by three independent constructs—regulations & policies, enforcement methods, and vision & approach. Strictly speaking, support was found for the perceived (negative) impact of OSHA's regulations & policies, enforcement methods, and vision & approach on the strategic safety improvement in the construction industry.

Descriptive analysis was performed to analyze the results. To identify the extent of negative impact of each of the measured indicators (survey items) with respect to OSHA's influence on strategic safety improvement in the construction industry, the mean values of survey responses for each item were used. Since each of the responses were measured on a five-point Likert-type scale (from 1 to 5), reverse coding was done for some of the statements which were positively worded. Hence a mean score of 5 in the final analysis represented worst perceived performance, while a mean score of 1 represented best perceived performance on the measure under consideration. A mean response score of 1.50 was considered least significant in terms of that particular measure generating (minimal) negative impact on the related construct. In order to distinguish the measures with respect to their extent of negative impact, the following indicator criticality index was used (Table 4.32).

Table 4.32: Indicator Criticality Indices

Mean Score Range	Indicator Criticality Index	Indicator Criticality Zone
>=4	6	Major High
3.50 – 3.99	5	Major Low
3.00 – 3.49	4	Moderate High
2.50 – 2.99	3	Moderate Low
2.00 – 2.49	2	Minor High
1.50 – 1.99	1	Minor Low
1.00 – 1.49	0	Non-Critical

Tables 4.33-4.35 show the mean response scores and indicator criticality indices for all the items measured in the survey, organized as per their respective constructs. The tables have been sorted in descending order of criticality of the indicators measured (based on their mean values).

Table 4.33: Regulations and Standards Construct

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
I	***Regulations and Standards***			
1	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker productivity.	4.57	6	Major High
2	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker acceptance to safety policies and procedures.	4.44	6	Major High
3	OSHA takes extraneous amount of time to actualize new regulations/ standards.	4.26	6	Major High
4	Existing OSHA procedures are not updated timely.	4.2	6	Major High
5	OSHA health and safety procedures/ instructions/ rules are not generally practicable (implementable).	3.71	5	Major Low
6	OSHA health and safety procedures/ instructions/ rules generally fail to reflect how the job is actually done.	3.68	5	Major Low
7	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that greatly restricts an organization's ability to develop as well as compete	3.67	5	Major Low
8	OSHA regulations and standards fail to incorporate current technology.	3.58	5	Major Low

Table 4.33: Regulations and Standards Construct (continued)

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
9	OSHA regulations/ procedures can be easily manipulated by some companies.	3.54	5	Major Low
10	OSHA regulations/ standards/ procedures are generally burdensome (trying to do too much without any practical advantage).	3.32	4	Moderate High
11	OSHA regulations are generally over-strict.	3.21	4	Moderate High
12	OSHA regulations/ standards/ procedures are generally confusing (not very clear to implement).	3.09	4	Moderate High
13	Substantial amount of capital has been needlessly wasted by your organization for complying with OSHA standards.	2.95	3	Moderate Low
14	Substantial amount of working hours have been needlessly lost by your organization for complying with OSHA standards.	2.81	3	Moderate Low
15	The cost of implementing OSHA regulations is usually unjustified as against their benefit in achieving reduced worker injury.	2.81	3	Moderate Low

[1]based on Table 4.32

Table 4.34: Enforcement Methods Construct

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
II	***Enforcement Methods***			
16	The priority of OSHA inspections is mostly centered towards imposing penalties, rather than preventing accidents and/ or identifying problems.	4.54	6	Major High
17	OSHA fails to provide adequate reward mechanisms.	4.43	6	Major High
18	OSHA performs inadequate number of inspections.	3.89	5	Major Low
19	OSHA generally seems more interested in issuing the fine rather than correcting the problem.	3.77	5	Major Low
20	OSHA's methods are mostly directed towards correcting only single events, such as the one your company was fined for.	3.88	5	Major Low
21	The penalties/ fines imposed by OSHA are not usually justified in proportion to the violation.	3.86	5	Major Low
22	OSHA inspections are unbalanced distributed among construction firms.	3.65	5	Major Low
23	OSHA inspections are unbalanced distributed among different types of construction expertise.	3.59	5	Major Low
24	OSHA training programs are generally ineffective.	3.55	5	Major Low
25	OSHA inspection procedures are generally ineffective.	3.53	5	Major Low

Table 4.34: Enforcement Methods Construct (continued)

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
26	OSHA is an overbearing bureaucracy with methods bearing little or no sensitivity to the needs & limitations of employers who are struggling to survive in a competitive marketplace.	3.19	4	Moderate High
27	OSHA's heavy fines restrict an organization's ability to develop as well as compete.	3.12	4	Moderate High
28	OSHA follow-up inspections (after initial citations have been issued) are usually performed at an unreasonably slower rate.	2.98	3	Moderate Low
29	OSHA deals with workplace accidents usually at an unreasonably slow rate.	2.84	3	Moderate Low

[1]based on Table 4.32

Table 4.35: Vision and Approach Construct

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone
III	***Vision and Approach***			
30	OSHA has generally failed to take a proactive approach in developing long term safety measures.	4.56	6	Major High
31	OSHA standards are mostly ineffective in setting up a Total Safety Culture on a construction jobsite (OSHA is the driving force to implement a total safety culture in a construction organization).	4.44	6	Major High

Table 4.35: Vision and Approach Construct (continued)

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
32	OSHA has not been concentrating enough on positive safety reinforcement.	4.42	6	Major High
33	The expenditures made for compliance with OSHA regulations and/ or paying for fines could be spent in a more strategic way that would create a safer work environment and a better understating of safety.	4.4	6	Major High
34	OSHA does not focus on the strategic picture by taking into consideration the underlying factors leading to accident (such as leadership, work pressure, communication) but rather focuses on the apparent causes of accident (such as lack of PPE).	4.23	6	Major High
35	OSHA emphasizes more on appointing supervisors to administer fines in the workplace, rather than appointing personnel to act as health and safety advisors.	3.91	5	Major Low
36	OSHA, as a safety organization, is not actively participating in necessary research activities to view and incorporate safety as an industrial development process, which would have improved ways construction organizations can incorporate safety in the industry.	3.85	5	Major Low

Table 4.35: Vision and Approach Construct (continued)

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
37	OSHA representatives do not usually provide follow up information pertaining to the incident such as: how the accident could be corrected or any appropriate training that could be utilized to ensure the incident is not repeated.	3.79	5	Major Low
38	OSHA should train their inspectors better regarding on how to facilitate developing a strategic safety culture in a construction organization leading to total safety.	3.75	5	Major Low
39	OSHA representatives do not usually provide information about how to improve safety strategically in your organization.	3.73	5	Major Low
40	OSHA is more devoted to inspections (monitoring) than to safety as a strategic concern.	3.71	5	Major Low
41	OSHA's safety approach restricts your organization by compelling it to increase investment in following procedures rather than investing in long-term safety objectives.	3.45	4	Moderate High
42	OSHA focuses more on the employer actions rather than on the employee safety, thereby increasing the short term expenses of the organization instead of the long term investment.	3.4	4	Moderate High

Table 4.35: Vision and Approach Construct (continued)

S. No.	OSHA Performance Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
43	OSHA places a heavy burden on organizations by forcing increased operational fees and the costs associated to retrofit outdated equipment rather than investing on improving the processes for achieving long-term (strategic) safety objectives.	3.24	4	Moderate High
44	OSHA's inspection and penalty approach of enforcement is an inappropriate and ineffective way to ensure workplace safety in the long-term.	3.18	4	Moderate High

[1]based on Table 4.32

After analyzing Tables 4.33-4.35, the key OSHA non-performance indicators (with criticality indices = 6), ranked in descending order of criticality (based on mean response score), are shown in Table 4.36. Table 4.36 also provides mean response rate, associated constructs, and criticality ranking for these key non-performance indicators. The first column in Table 4.36 provides the serial number of these indicators as given in Tables 4.33-4.35.

Table 4.36: Key OSHA Non-Performance Indicators – All Constructs

S. No.	Non-Performance Indicator	Mean Response Score (Scale 1-5)	Construct	Indicator Criticality Ranking
1	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker productivity.	4.57	Regulations and Standards	1
30	OSHA has generally failed to take a proactive approach in developing long term safety measures.	4.56	Vision and Approach	2
16	The priority of OSHA inspections is mostly centered towards imposing penalties, rather than preventing accidents and/ or identifying problems.	4.54	Enforcement Methods	3
2	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker acceptance to safety policies and procedures.	4.44	Regulations and Standards	4
31	OSHA standards are mostly ineffective in setting up a Total Safety Culture on a construction jobsite (OSHA is the driving force to implement a total safety culture in a construction organization).	4.44	Vision and Approach	5
17	OSHA fails to provide adequate reward mechanisms.	4.43	Enforcement Methods	6
32	OSHA has not been concentrating enough on positive safety reinforcement.	4.42	Vision and Approach	7
33	The expenditures made for compliance with OSHA regulations and/ or paying for fines could be spent in a more strategic way that would create a safer work environment and a better understating of safety.	4.40	Vision and Approach	8
3	OSHA takes extraneous amount of time to actualize new regulations/ standards	4.26	Regulations and Standards	9

Table 4.36: Key OSHA Non-Performance Indicators – All Constructs (continued)

S. No.	Non-Performance Indicator	Mean Response Score (Scale 1-5)	Construct	Indicator Criticality Ranking
34	OSHA lacks strategic focus on underlying factors leading to accident (such as leadership, work pressure, communication) but rather place emphasis on the apparent causes of accident (such as lack of PPE).	4.23	Vision and Approach	10
4	OSHA's safety procedures are not updated as frequently as needed.	4.20	Regulations and Standards	11

Further assessment of Tables 4.33-4.35 – to identify construct criticality ranking (based on a value of weighted mean response score for each construct) – results in Table 4.37. Table 4.37 has been arranged in descending order of construct criticality and also provide construct criticality ranking.

Table 4.37: Construct Criticality Ranking

Construct	Weighted Mean Response Score (Scale 1-5)	Construct Criticality Ranking
Vision and Approach	3.87	1
Enforcement Methods	3.63	2
Regulations and Standards	3.59	3

The major OSHA non-performance indicators (with an indicator criticality index = 5 or 6) constitute 16 out of a total of 44 indicators i.e. 36.36%. The moderate OSHA non-performance indicators (with an indicator criticality index = 3 or 4) constitute 18 out of a total of 44 indicators i.e. 40.90%. Minor OSHA non-performance indicators (with an indicator criticality index = 1 or 2) constitute 6 out of a total of 44 indicators i.e. 13.64%.

The remaining 4 indicators (9.10%) are not perceived by the industry as negative aspects of OSHA performance.

The above results indicate that OSHA is not performing at par in terms of achieving strategic safety improvement in the construction industry. The key OSHA non-performance construct (Vision and Approach) also reinstate the same conclusion, i.e. OSHA needs to improve on its vision and approach in order to strategically improve safety in the industry. The key change in OSHA's strategic approach, as reflected from the findings, should be "inculcating total safety and continuous improvement through teamwork, research and positive reinforcement" as against its current "inspection and penalty" approach. OSHA needs to work with the companies and not against them in order to achieve the strategic goal of zero accidents in the industry. This is a problem that needs to be addressed by reverting to the fundamentals of what an organization like OSHA is to accomplish.

4.4.4. Survey 4: Investigation of the state of adoption and implementation of safety as a total management process in a contracting firm's management system

4.4.4.1.Description

Today's construction projects are growing in complexity and in order to succeed on the global level, construction organizations must not approach construction safety and health as just another step in avoiding unwanted accidents or federal fines, but as a strategic tool, that if implemented effectively, will have the potential to maximize competitiveness and profit. This strategic approach to safety can be accomplished via a Total Safety management (TSM) philosophy which finds its roots from the Total Quality management (TQM) principles. TSM is a performance oriented safety initiative that involves all the members of an organization in establishing and maintaining a work environment that is safe and conducive to quality and productivity. The primary purpose of TSM is to provide excellence in safety through continuous improvements of products and processes by the total involvement and dedication of each individual who is in any way a part of that product/process. It is a structured approach to improvement. If correctly applied, it will assist a construction company in improving its performance. It involves a strong commitment to two guiding principles: customer satisfaction and continuous improvement. TSM follows the same sets of standards as TQM and provides a competitive advantage to the companies that implement it, by establishing a safer working place that leads to a continuous and sustainable improvement in peak performance, thereby achieving and maintaining the goal of zero accidents.

As found by other surveys in this research, inspection traditionally has been one of the key attributes of a safety system in the construction industry. In regards to inspection related to quality, Deming says, "Routine 100% inspection is the same thing as planning for defects - acknowledgement that the process cannot make the product correctly, or that the specifications made no sense in the first place. Quality comes not from inspection, but from improvement of the process. The same philosophy is applicable to safety as well. In terms of safety, this does not mean that inspection ceases. Instead, it means that more effort should be put into preventing errors and injuries.

The construction industry has been following a path that has led to lack of trust and confidence, adversarial relations, unsafe behaviors, and increased arbitration and litigation. The industry has become increasingly reliant on burdensome specifications and compliance. This has led the owners and regulatory agencies to shift more of the risks to the contractors. The net outcome is that the construction industry has been bogged down with paperwork, defensive posturing, and generally tends to have a hostile attitude towards regulatory agencies and other participants. TSM can help reverse this trend. Although, not a magic pill or panacea for all illnesses, it will, if properly implemented, help construction companies improve on a sustainable basis in order to achieve the goal of zero accidents, as well as help all the parties to come closer.

Although 'Total Safety Management' has been a magic word for a while now, methods and techniques to implement safety as a total management process in construction Industry are still to be developed. TSM places emphasis on prevention and not correction. The goal is work that is 100% free of errors and free of accidents. To do this, it is necessary to focus on "processes" and not "end results". The primary purpose of this part of the research was to investigate the adoption and implementation of TSM in the construction industry. Literature review highlighted that no accurate information regarding the extent of usage of safety as a total management process in the construction industry was available. Hence this survey was conducted wherein the contractors and subcontractors were asked to identify the extent of adoption and implementation of TSM as a process in their businesses. The results of the survey included measurements on the extent of knowledge of the industry personnel about TSM, and the use of techniques of implementing TSM in the construction industry. The survey further reflected industry opinions as to the benefits and obstacles of the application of TSM techniques to the construction industry in terms of achieving and sustaining the goal of zero accidents. This dimension of research is significant not only to understand the role of TSM in strategically improving safety in the construction industry but also to determine how

TSM approaches positively impact safety performance and the worker safety behaviors through an organization's ability to translate, integrate, and ultimately institutionalize TSM behaviors into everyday practice on the job.

For the purpose of this study, the evaluation of the current state of safety improvement strategies in use by the construction organizations and the readiness of the organizations to adopt and implement safety as a total management process in their routine works was done by conducting a structured survey in the construction industry. This survey examined the perception, approaches and practices of construction firms as a predictive tool to demonstrate how safety is operational as a total management process within these organizations. A survey was designed and distributed to contractor and subcontractor managerial staff (including top management and middle/ project management) for assessing the aforementioned aspects by taking into account the organizations' perception towards safety as a total management process, the use of safety improvement strategies in the companies, the state of employee involvement and empowerment, the state of safety improvement training, the perceived benefits and obstacles of TSM, and the readiness of the companies to implement safety as a total management process in their routine works. Conclusions drawn from this research will strengthen or weaken the argument that the safety improvement strategies currently adopted by construction organizations in the U.S. are generally focused towards safety compliance rather than total safety management.

From the perspective of the overall objective of this dissertation, the underlying objective of this research study was to collect and analyze data on safety improvement practices, and TSM adoption and readiness, which would serve as a basis to establish the rationale of this research: need for a strategic zero-accident safety improvement framework in the construction industry to achieve continuous and sustainable safety improvement. There is no intent on the part of the author to imply that the identified main and sub causes (factors) of lack of TSM adoption in the construction industry are in any way statistically significant.

4.4.4.2.Methodology

Structured surveys were conducted to achieve the study objectives. The methodology of survey development and administration was the same as discussed in section 3.2.2.3.

The following sections illustrate the major findings of the research conducted for the key question at hand: Are the safety improvement strategies currently adopted by construction organizations instrumental in nurturing safety as a total management process in their organizations (in order to strategically improve safety in the construction industry)?

4.4.4.3.Data Collection

On the basis of literature review, six key constructs (factors) were identified along with a number of associated indicators (observable items in terms of survey questions) to analyze the current state of adoption and the state of readiness of construction organizations in implementing safety as a total management process in their routine operations. The constructs are described in the following sub-section.

4.4.4.3.1. Constructs

The following five constructs (factors) were used to analyze the various facets of the state of implementation of safety as a total management process in construction organizations.

4.4.4.3.1.1.Knowledge of TSM

This construct consisted of various indicators determining the knowledge of the industry in relation to safety as a total management process in construction businesses. Aspects diagnosed included knowledge of existing construction industry programs implementing TSM, perceived methods of implementing TSM, and perception of the factors significant in developing and implementing a TSM program.

4.4.4.3.1.2.Strategic Vision of Safety

This construct consisted of various indicators determining the strategic vision of the industry in regards to appreciating safety as a total management process in construction businesses. Aspects diagnosed included perceived strategic impacts of poor safety performance, perceived effectiveness of a TSM program, perceived effectiveness of OSHA regulations in terms of implementing TSM, company's view of safety as an integral business value, company's view of safety as a strategic tool to achieve zero accidents and to attain competitive advantage, and the company's strategic policy towards safety.

4.4.4.3.1.3.Strategic Approach to Safety Improvement

This construct consisted of a number of indicators determining the nature of safety improvement programs in construction organizations with respect to their strategic focus towards TSM. Aspects diagnosed included employee awareness of the program, strategic focus of the program, factors motivating the initiation of the program, key objectives of the program, steps taken in the program development and implementation, level of success of the program in terms of improved worker safety behaviors and improved relationships with customers and suppliers, company strategy to determine the effectiveness of the program, personnel support to implement the program, orientation of safety training towards TSM, provision of formal training in TSM or other safety improvement philosophies to employees, and emphasis of training on process improvement; data gathering & analysis; teamwork; communication; and zero accident strategies.

4.4.4.3.1.4.Employee Involvement and Empowerment

This construct consisted of a number of indicators determining the nature and extent of employee involvement and empowerment in company's safety improvement program. Aspects diagnosed included level of empowerment of employees to make significant safety improvement suggestions and changes to operations, availability of an anonymous way for employees to make safety improvement suggestions, importance of employee input in the company's safety improvement program, extent to which the employees provide input that is useful in making continual safety improvements to the organization, inclusion of employee feedback in the safety decision making process, presence of a mentoring program for new employees to develop safe working habits, presence of incentive programs to reward workers; supervisors; superintendents; or specific teams for outstanding safety performance and/or for generating ideas to reduce the number of accidents, level of feedback collected from employees for various safety related areas, and methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM.

4.4.4.3.1.5.Readiness to Embrace TSM

This construct consisted of a number of indicators determining the readiness of construction organizations to embrace safety as a total management process in their businesses. Aspects diagnosed included characteristics of company's culture promoting safety conscience, involvement of various organizational levels in safety efforts, company support to implement safety as a total management process, desirable worker behaviors under work pressure, company strengths in safety, significance of safety in company's strategic plan and mission statement, knowledge and understanding by all members of the organization of the following: company's safety mission, team's safety goal; team's success definition; how team decisions are made; responsibilities and authorities of all team members; desirable behaviors in case of unforeseen inhibitors impeding progress; and how unsafe team members will be guided for improvement, openness and honesty policy in the organization, decision support by all levels of employees, involvement of whole organization to accomplish safety and health goals, involvement of whole organization to assess the safety precautions and rules, involvement of whole organization in taking the responsibility of the accidents and their effects, peer pressure among workers to work in a safe and healthy manner, recognition and reward for safe practices, independent (cold eye) safety reviews and ratings, use of positive reinforcement for good safety practices, and viewing at the past safety performance (safety history) of the subcontractors/ suppliers and prospective employees as an important criterion for selection & hiring.

4.4.4.3.2. Questionnaire

A quantitative research method was chosen to investigate the state of adoption and implementation of safety as a total management process in the construction industry, since it was exploratory in nature. Questionnaire survey was used in order to facilitate the collection of information from construction organizations. All indicators (observed variables) were measured through a five-point Likert-type response format. Items, relating to each of the constructs, were used in the form of statements to measure individual constructs under investigation. Participants were asked to endorse the statements using a five-point Likert-type scale (from 1=‘‘strongly disagree’’ to 5=‘‘strongly agree’’). Questionnaire survey is presented in Appendix D.

In addition to the five constructs described above, a number of measures determining the perceived benefits and obstacles in implementing TSM in the construction industry were also included in the questionnaire. This last part of the questionnaire was aimed at collecting industry perceptions in relation to TSM benefits including: increased profits; improved performance; improved safety records; increased employee morale; provision of a check-and-balance mechanism at different stages of a project lifecycle; avoidance of costly redesign or project delay by addressing hazard issues as early as possible; and provision of traceable and effective hazard management, and industry perceptions in relation to TSM obstacles including: changing attitudes and behaviors; schedule and cost pressures; conflicts with short-term targets; lack of education and training to drive the improvement process; lack of top-management commitment/ understanding; lack of employee commitment/ understanding; tendency to cure symptom rather than cause; lack of expertise/ resources in TSM (or continuous safety improvement); and current bidding climate.

To achieve acceptable levels of measurement reliability and validity, draft questionnaires were constructed and pretested via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their top managers and middle/ project managers, all having expertise in or exposure to safety issues. Their input was used to refine the original questionnaire. The questionnaire contained, in its final form, a total of 139 statements (124 statements about the state of adoption and implementation of safety as a total management process, and 15 statements about the perceived benefits and obstacles towards implementing safety as a total management process). The research targeted top management and middle/ project management personnel from general contractor and subcontractor organizations as the survey sample.

Based on all the gathered information, descriptive analysis was performed and the results are discussed in the following section.

4.4.4.4.Data Analysis

The indicators (questionnaire items) in the survey were assumed to reflect the unobserved, underlying construct, with the construct giving rise to (or ‘‘causing’’) the observed measures. For example, constructs such as strategic approach to safety improvement, and employee involvement & empowerment are typically viewed as underlying factors that give rise to something that is observed. Accordingly, their indicators tend to be realized as reflective.

4.4.4.4.1. Assessment of Data Reliability and Validity

Prior to data analysis, three measurement properties need to be examined to ensure that the data has a satisfactory level of reliability and validity (Fornell and Larcker 1981). The first of these is the individual item reliability, where loadings (or simple correlations) of the items on their respective constructs are assessed, using 0.70 as a cutoff point (Fornell and Larcker 1981). Exceeding this value simply implies that less than half of the item’s variance is due to error. Obtained values for items exceeded this threshold, with all loadings in the range of 0.75–0.90, demonstrating the satisfactory level of individual item reliability.

Convergent validity (also referred to as the homogeneity of the construct or composite reliability) is the second measurement property to be examined, and is evaluated by Cronbach's alpha. The Cronbach's alpha obtained for each construct is listed in Table 4.38. All constructs have acceptable convergent validity, as a value of 0.70 is usually accepted as the minimum desired value of the Cronbach's alpha (Litwin 1995).

The third measurement property is the discriminant validity – that is, the extent to which each construct differs from other constructs in the analysis. It is assessed by using the average variance extracted ($A\boldsymbol{v}$), suggested by Fornell and Larcker (1981) (Table 4.38). This measure should be greater than the variance shared between the construct and other constructs in the model (i.e., the squared correlation between two constructs). This can be demonstrated in the correlation matrix, shown in Table 4.39, which includes the correlations between different constructs in the lower left off-diagonal elements of the matrix, and the square root of the average variance extracted ($A\boldsymbol{v}$) calculated for each of the constructs along the diagonal. Having all of the diagonal elements greater than any other corresponding row or column implies adequate discriminant validity.

Having satisfied the three measurement properties, it can be concluded that the constructs are measured with adequate precision.

Table 4.38: Convergent Validity of Independent Constructs

Construct	Cronbach's alpha	Average variance extracted (*Av*)
1. Knowledge of TSM	0.846	0.72
2. Strategic Vision of Safety	0.875	0.74
3. Strategic Approach to Safety Improvement	0.864	0.78
4. Employee Involvement & Empowerment	0.891	0.67
5. Readiness to Embrace TSM	0.821	0.70

Table 4.39: Discriminant Validity Analysis

Construct	Construct				
	1	2	3	4	5
1. Knowledge of TSM	**0.85**	-	-	-	-
2. Strategic Vision of Safety	0.18	**0.86**	-	-	-
3. Strategic Approach to Safety Improvement	0.07	0.14	**0.88**	-	-
4. Employee Involvement & Empowerment	0.20	0.09	0.15	**0.82**	-
5. Readiness to Embrace TSM	0.15	0.16	0.17	0.14	**0.84**

4.4.4.4.2. Results and Conclusion

This section presents the results of the survey. State of adoption and implementation of safety as a total management process in construction organizations was determined by five independent constructs— knowledge of TSM, strategic vision of safety, strategic approach to safety improvement, employee involvement & empowerment, and readiness to embrace TSM. Strictly speaking, support was found for factors impeding the strategic adoption and implementation of safety as a total management process in construction organizations. Additionally, industry perception was collected as for the benefits and obstacles in TSM implementation in the construction industry.

Descriptive analysis was performed to analyze the results. To assess the extent of impact of each of the measured indicators (survey items) with respect to the state of adoption and implementation of safety as a total management process in construction organizations, the mean values of survey responses for each item were used. Except for the TSM benefits and obstacles data collected (the analysis procedure of which will be described later), a mean score of 5 in the final analysis represented best performance on the measured indicator, while a mean score of 1 represented worst performance on the measure under consideration. A mean response score of 4.50 was considered least significant in terms of that particular measure generating (minimal) negative impact on the related construct. In order to distinguish the measures with respect to their extent of impact, an indicator criticality indexing and zoning criteria was used (Table 4.40).

Table 4.40: Indicator Criticality Indices & Zones

Mean Score Range	Indicator Criticality Index	Indicator Criticality Zone
<=2	6	Major High
2.01-2.50	5	Major Low
2.51 – 3.00	4	Moderate High
3.01-3.50	3	Moderate Low
3.51 – 4.00	2	Minor High
4.01 – 4.50	1	Minor Low
4.51 – 5.00	0	Non-Critical

It is important to note here that that owing to the nature of some of the statements provided in the questionnaire, a high mean response score for these statements, although represented better performance on the measure, actually represented poor performance in terms of that particular measure affecting the related TSM construct. For instance, the statement in the questionnaire: My company's safety policy can be best defined as "implementation of a set of safety rules by the company with punitive measures for violators" received a mean response score of 3.56 on a scale of 4. This can be interpreted as having 3.56 out of every 5 respondents agreed to this statement. However, since this statement actually interprets that the company's safety policy is oriented towards safety compliance only and not strategic safety improvement, a high mean response on this measure, in fact, indicates a high negative impact on the company's safety policy being conducive to TSM. Hence the result of this and such statements needed to be reversed in order to correctly interpret their level of criticality in terms of positively or negatively affecting the TSM culture in a construction organization, which was the primary factor to be assessed. Consequently, the mean response rate of 3.56 was reversed to 1.44 (equivalent to 5-3.56) in order to assess that measure in terms of the overall objective (TSM performance). This is indicated in brackets under the "Mean" column in the proceeding tables depicting the results. This is done for all such statements.

Tables 4.41-4.45 show the mean response scores and indicator criticality indices for all the items measured in the survey, organized under their respective constructs. The tables have been sorted in descending order of criticality of the indicators measured (based on their mean values).

Table 4.41: Knowledge of TSM Construct

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
I	***Knowledge of TSM***			
1	TSM can be achieved by measuring and keeping records of the number of accidents and incidents and applying punitive measures to workers that are caught violating safety rules.	3.65 (1.35)	6	Major High
2	I am aware of construction industry programs implementing TSM.	1.44	6	Major High
3	TSM programs should be based on scientific decision making.	2.54	4	Moderate High
4	TSM can be achieved by making and maintaining a safe and healthy workplace as part of the company's strategic plan.	3.08	3	Moderate Low
5	TSM can be achieved by ensuring safe working through positive reinforcement and advice and improving by adopting good practice that exceeds legislative requirements.	3.27	3	Moderate Low
6	TSM programs should be strategically focused.	3.38	3	Moderate Low
7	TSM can be achieved by motivating staff through a measurement and reward scheme and providing the skills and information to enable staff to work safely via training and its intranet.	3.65	2	Minor High
8	TSM programs should focus on peak performance.	3.65	2	Minor High
9	TSM programs should have unity of purpose.	3.96	2	Minor High
10	TSM programs should be committed to employee empowerment.	4.04	1	Minor Low
11	TSM programs should be committed to continual improvement.	4.08	1	Minor Low
12	TSM programs should be performance and process oriented.	4.15	1	Minor Low

Table 4.41: Knowledge of TSM Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
13	TSM programs are largely dependent on executive-level commitment.	4.15	1	Minor Low
14	TSM programs should contain comprehensive, ongoing training.	4.31	1	Minor Low
15	TSM programs should be teamwork oriented.	4.38	1	Minor Low

[1]based on Table 4.40

Table 4.42: Strategic Vision of Safety Construct

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
II	***Strategic Vision of Safety***			
16	My company views safety as a tool to increase profits.	2.2	5	Major Low
17	My company views safety as a competitive advantage.	2.22	5	Major Low
18	My company's safety policy can be best defined as "Implementation of a set of safety rules by the Company with punitive measure for violators."	3.56 (1.44)	6	Major High
19	My company's safety policy can be best defined as "a set of processes developed to manage safety aspects of a project including encouraging, measuring and rewarding behavior that creates a safe working environment rather than catching people who break the rules."	2.44	5	Major Low

Table 4.42: Strategic Vision of Safety Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
20	My company's safety policy can be best defined as "a performance-and-process-control oriented approach to safety and health management that gives organization sustainable competitive advantage in the marketplace by establishing a safe and healthy work environment that is conducive to consistent peak performance and that is improved continually."	2.23	5	Major Low
21	Poor safety performance decreases productivity and organizational performance.	2.55	4	Moderate High
22	The company management strongly believes that excellence in safety would positively affect the ability to achieve excellence in other areas; e.g. production, etc.	2.64	4	Moderate High
23	My company views safety and health as an integral part of its business.	2.83	4	Moderate High
24	My company believes that poor safety performance restricts strategic organizational growth.	2.86	4	Moderate High
25	OSHA regulations provide a driving force to implementing TSM.	2.9	4	Moderate High
26	My company views safety as achieving zero accidents.	2.95	4	Moderate High
27	My company views safety as elimination of hazards.	3.22	3	Moderate Low
28	A TSM program is (will be) beneficial for my organization.	4.04	1	Minor Low

[1]based on Table 4.40

Table 4.43: Strategic Approach to Safety Improvement Construct

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
III	***Strategic Approach to Safety Improvement***			
29	Steps taken in implementing my organization's safety improvement program include: "A dollar value has been assigned to the cost of unsafe behaviors".	2.02	5	Major Low
30	"Obtaining client satisfaction" is a major objective of my organization's safety improvement program.	2.26	5	Major Low
31	Training currently emphasizes: data gathering & analysis.	2.28	5	Major Low
32	"Pressure from competitors" was a key factor that provided the motivation to start the safety improvement program.	2.33	5	Major Low
33	Steps taken in implementing my organization's safety improvement program include: "Benchmarks for improvement have been defined".	2.38	5	Major Low
34	"Environmental issues/considerations" was a key factor that provided the motivation to start the safety improvement program.	2.49	5	Major Low
35	"Increasing productivity" is a major objective of my organization's safety improvement program.	2.51	4	Moderate High
36	Steps taken in implementing my organization's safety improvement program include: "Organizing a multi-disciplinary team".	2.55	4	Moderate High
37	Company's safety training is oriented towards TSM (or continuous safety improvement).	2.59	4	Moderate High
38	The company's safety improvement program is centered on Total Safety Management and/ or zero accident strategies.	2.65	4	Moderate High

Table 4.43: Strategic Approach to Safety Improvement Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
39	"Safety of processes" was a key factor that provided the motivation to start the safety improvement program.	2.67	4	Moderate High
40	Training currently emphasizes: process improvement.	2.69	4	Moderate High
41	Steps taken in implementing my organization's safety improvement program include: "Data has been collected to measure the safety performance".	2.72	4	Moderate High
42	"Demanding customers" was a key factor that provided the motivation to start the safety improvement program.	2.78	4	Moderate High
43	"Need to reduce costs and improve performance" was a key factor that provided the motivation to start the safety improvement program.	2.82	4	Moderate High
44	Steps taken in implementing my organization's safety improvement program include: "An educational program has been implemented".	2.84	4	Moderate High
45	"My company's chief executive" was a key factor that provided the motivation to start the safety improvement program.	2.88	4	Moderate High
46	Steps taken in implementing my organization's safety improvement program include: "Safety problems have been identified".	2.88	4	Moderate High
47	Training currently emphasizes: teamwork.	2.9	4	Moderate High
48	Training currently emphasizes: communication.	2.92	4	Moderate High
49	"Achieving zero accidents" was a key factor that provided the motivation to start the safety improvement program.	2.94	4	Moderate High

Table 4.43: Strategic Approach to Safety Improvement Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
50	"Ensuring involvement of employees in the safety building effort" is a major objective of my organization's safety improvement program.	2.96	4	Moderate High
51	Steps taken in implementing my organization's safety improvement program include: "An internal awareness program is underway".	2.98	4	Moderate High
52	Training currently emphasizes: zero accident strategies.	2.98	4	Moderate High
53	Formal training in TSM or other safety improvement philosophies is given to employees.	3.11	3	Moderate Low
54	After the implementation of my safety improvement program, the relationship with my customers and suppliers has improved.	3.13	3	Moderate Low
55	My organization's safety improvement program can be described as formal with widespread employee awareness.	3.14	3	Moderate Low
56	As part of the management team, we have a TSM Steering Committee/ a TSM Facilitator/ a safety improvement project team.	3.16	3	Moderate Low
57	The company provides feedback loops to determine if the safety improvement practices are working.	3.23	3	Moderate Low
58	After the implementation of my safety improvement program, worker behaviors have improved.	3.29	3	Moderate Low
59	"Employee safety" was a key factor that provided the motivation to start the safety improvement program.	3.42	3	Moderate Low
60	"Health and Safety agencies (like OSHA)" was a key factor that provided the motivation to start the safety improvement program.	3.89	2	Minor High

[1]based on Table 4.40

Table 4.44: Employee Involvement & Empowerment Construct

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
IV	***Employee Involvement & Empowerment***			
61	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: serving effectively on improvement teams".	2.05	5	Major Low
62	There is an anonymous way for employees to make safety improvement suggestions. e.g. drop box.	2.34	5	Major Low
63	The company has a mentoring program for all new employees to develop safe working habits.	2.56	4	Moderate High
64	The company has incentive programs to reward workers, supervisors, superintendents, or specific teams for outstanding safety performance and/or for generating ideas to reduce the number of accidents.	2.68	4	Moderate High
65	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "practicing hazard identification techniques constantly".	2.71	4	Moderate High
66	The level of feedback collected from employees is very significant for setting safety goals.	2.76	4	Moderate High
67	The level of feedback collected from employees is very significant for selecting safe projects.	2.79	4	Moderate High
68	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "encouraging fellow employees to work safely".	2.89	4	Moderate High

Table 4.44: Employee Involvement & Empowerment Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
69	The extent to which the employees provide input that is useful in making continual safety improvements to the organization is very significant.	2.94	4	Moderate High
70	The level of feedback collected from employees is very significant for measuring safety improvement.	2.94	4	Moderate High
71	The level of feedback collected from employees is very significant for identifying solutions.	2.96	4	Moderate High
72	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "setting positive examples of working safely".	3.16	3	Moderate Low
73	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "recommending accident prevention strategies".	3.16	3	Moderate Low
74	Employee feedback is almost always included in the safety decision making process.	3.28	3	Moderate Low
75	Employees are empowered to make significant safety improvement suggestions and changes to operations.	3.42	3	Moderate Low
76	The level of feedback collected from employees is very significant for identifying safety issues.	3.44	3	Moderate Low
77	The importance of employee input in my company's safety improvement program is very high.	3.54	2	Minor High

[1]based on Table 4.40

Table 4.45: Readiness to Embrace TSM Construct

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
V	***Readiness to Embrace TSM***			
78	All team members understand how unsafe team members will be guided for improvement.	2.12	5	Major Low
79	Decisions are supported by all in my organization.	2.42	5	Major Low
80	All team members understand how team decisions are made.	2.54	4	Moderate High
81	"Company executives/ managing directors" are involved in safety management efforts/ activities.	2.54	4	Moderate High
82	"Appropriate storage practices" are my company's strength in terms of safety.	2.58	4	Moderate High
83	Company looks at the past safety performance (safety portfolio) of a prospective employee as an important criterion for selection.	2.72	4	Moderate High
84	"Consistent commitment to improvement" promotes safety conscience in my company.	2.74	4	Moderate High
85	The organization has a mission statement with specific responsibilities for approval of recommendations for improvement of the work environment.	2.82	4	Moderate High
86	My company provides (or strives to provide): safety information.	2.82	4	Moderate High
87	In my company, we would never compromise safety to meet deadlines.	2.86	4	Moderate High
88	"Employee participation" promotes safety conscience in my company.	2.86	4	Moderate High
89	The organization has a mission statement with specific responsibilities for building safety and health concerns into the strategic plan.	2.88	4	Moderate High

Table 4.45: Readiness to Embrace TSM Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone
90	The responsibility of the accidents and their effects belongs to the whole organization.	2.88	4	Moderate High
91	"Management leadership" promotes safety conscience in my company.	2.88	4	Moderate High
92	Team's success is understood by all team members in my organization.	2.88	4	Moderate High
93	Team's goal is understood by all team members in my organization.	2.92	4	Moderate High
94	"An active TSM steering committee/ safety improvement team" is my company's strength in terms of safety.	2.96	4	Moderate High
95	All team members understand their authority within the team and that of all other team members.	2.96	4	Moderate High
96	All team members know the responsibilities of all other team members.	3.02	3	Moderate Low
97	"A capable and committed safety director" is my company's strength in terms of safety.	3.12	3	Moderate Low
98	When unforeseen inhibitors impede progress all members know what to do.	3.12	3	Moderate Low
99	The whole organization is responsible to follow and get involved in the safety & health mission accomplishment.	3.12	3	Moderate Low
100	My company provides (or strives to provide): management encouragement towards safety.	3.12	3	Moderate Low
101	Company uses the method of positive reinforcement for good safety practices.	3.14	3	Moderate Low
102	Safety practices are recognized and rewarded.	3.17	3	Moderate Low
103	The whole organization is responsible to assess the safety precautions and rules.	3.17	3	Moderate Low

Table 4.45: Readiness to Embrace TSM Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
104	Company follows independent (cold eye) safety reviews and ratings.	3.19	3	Moderate Low
105	My company provides (or strives to provide): safe working environment.	3.23	3	Moderate Low
106	"Company administration and support" are involved in safety management efforts/ activities.	3.24	3	Moderate Low
107	"Self accountability" promotes safety conscience in my company.	3.25	3	Moderate Low
108	My company provides (or strives to provide): clearly defined mission statement.	3.25	3	Moderate Low
109	"Commitment by senior management" is my company's strength in terms of safety.	3.27	3	Moderate Low
110	"Individual employees" are involved in safety management efforts/ activities.	3.28	3	Moderate Low
111	Peer pressure exists among workers to work in a safe and healthy manner.	3.28	3	Moderate Low
112	Everyone is open and honest with each other in my organization.	3.32	3	Moderate Low
113	Safety mission is understood by all team members in my organization.	3.32	3	Moderate Low
114	Company looks at the past safety performance (safety history) of the subcontractors/ suppliers as an important criterion for selection.	3.36	3	Moderate Low
115	The organization has a mission statement with specific responsibilities for regular review of the safety and health program in order to keep up with the safety best practices.	3.43	3	Moderate Low
116	"A comprehensive safety and health plan" is my company's strength in terms of safety.	3.48	3	Moderate Low

Table 4.45: Readiness to Embrace TSM Construct (continued)

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
117	My company provides (or strives to provide): safety manager or safety committee.	3.54	2	Minor High
118	"Safe facilities" are my company's strength in terms of safety.	3.54	2	Minor High
119	"Up-to-date safety procedures" is my company's strength in terms of safety.	3.55	2	Minor High
120	My company provides (or strives to provide): formal, written statement of corporate safety policies and objectives.	3.85	2	Minor High
121	"Safe equipment" is my company's strength in terms of safety.	4.28	1	Minor Low
122	"Project managers" are involved in safety management efforts/ activities.	4.3	1	Minor Low
123	"Site managers" are involved in safety management efforts/ activities.	4.42	1	Minor Low
124	My company provides (or strives to provide): personal protective equipment.	4.52	0	Non-Critical

[1]based on Table 4.40

For the TSM benefits and obstacles data collected, a mean score of 5 in the final analysis represented maximum perceived impact by the measured indicator, while a mean score of 1 represented minimum perceived impact by the measured indicator. Note that a mean score of 5 represents maximum perceived benefit by a benefit measure while the same mean score of 5 represents maximum barrier to TSM implementation by an obstacle measure. A mean response score of 3.01 or above (3 represents a neutral response) was considered significant in terms of that particular measure being considered as a benefit or obstacle to TSM implementation. In order to distinguish the measures with respect to their extent of impact, the following measure impact index was used (Table 4.46). The results are depicted in Tables 4.47-4.48.

Table 4.46: Measure Impact Indices and Zones

Mean Score Range	Impact Index	Impact Zone
<=2	0	No Significant Impact
2.01-2.50	1	Minor Low
2.51 – 3.00	2	Minor High
3.01-3.50	3	Moderate Low
3.51 – 4.00	4	Moderate High
4.01 – 4.50	5	Major Low
4.51 – 5.00	6	Major High

Table 4.47: TSM Benefits

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Measure Impact Index[1]	Measure Impact Zone[1]
VI	***<u>TSM Benefits</u>***			
125	TSM improves performance.	4.36	3	Major
126	TSM increases employee morale.	4.28	2	Moderate
127	TSM increases profits.	4.15	2	Moderate
128	TSM provides the opportunity to avoid costly redesign or project delay by addressing hazard issues as early as possible.	3.98	2	Moderate
129	TSM provides traceable and effective hazard management system.	3.91	2	Moderate
130	TSM provides a check-and-balance mechanism at different stages of a project lifecycle.	3.79	2	Moderate

[1]based on Table 4.46

Table 4.48: TSM Obstacles

S. No.	TSM Statement	Mean Response Score (Scale 1-5)	Indicator Criticality Index[1]	Indicator Criticality Zone[1]
VI	***<u>TSM Obstacles</u>***			
131	"Changing attitudes and behaviors" is an obstacle in TSM implementation.	4.47	3	Major
132	"Emphasis on short-term objects" is an obstacle in TSM implementation.	4.42	3	Major
133	"Lack of top-management commitment/ understanding" is an obstacle in TSM implementation.	4.37	3	Major
134	"Lack of education and training to drive the improvement process" is an obstacle in TSM implementation.	4.12	2	Moderate
135	"Schedule and cost treated as the main priorities" is an obstacle in TSM implementation.	4.11	2	Moderate
136	"Current bidding climate" is an obstacle in TSM implementation.	4.05	2	Moderate
137	"Lack of employee commitment/ understanding" is an obstacle in TSM implementation.	3.79	2	Moderate
138	"Lack of expertise/resources in TSM" is an obstacle in TSM implementation.	3.64	1	Minor
139	"Tendency to cure symptom rather than eradicate the root cause" is an obstacle in TSM implementation.	3.53	1	Minor

[1]based on Table 4.46

After analyzing Tables 4.41-4.45, the major critical indicators reflecting lack of adoption and implementation of TSM in construction contracting organizations (with criticality indices = 5 or 6), ranked in descending order of criticality (based on mean response score), are shown in Table 4.49. Table 4.49 also provides mean response rate, associated constructs, and indicator criticality ranking for these key TSM impeding indicators. The first column in Table 4.49 provides the serial number of these indicators as given in Tables 4.41-4.45.

Table 4.49: Key TSM Impeding Indicators – All Constructs

S. No.	TSM Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
1	TSM can be achieved by measuring and keeping records of the number of accidents and incidents and applying punitive measures to workers that are caught violating safety rules.	3.65 (1.35)	Knowledge of TSM	1
2	I am aware of construction industry programs implementing TSM.	1.44	Knowledge of TSM	2
18	My company's safety policy can be best defined as "Implementation of a set of safety rules by the Company with punitive measure for violators."	3.56 (1.44)	Strategic Vision of Safety	3
29	Steps taken in implementing my organization's safety improvement program include: "A dollar value has been assigned to the cost of unsafe behaviors".	2.02	Strategic Approach to Safety Improvement	4
61	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: serving effectively on improvement teams".	2.05	Employee Involvement and Empowerment	5
78	All team members understand how unsafe team members will be guided for improvement.	2.12	Readiness to Embrace TSM	6
16	My company views safety as a tool to increase profits.	2.2	Strategic Vision of Safety	7
17	My company views safety as a competitive advantage.	2.22	Strategic Vision of Safety	8

Table 4.49: Key TSM Impeding Indicators – All Constructs (continued)

S. No.	TSM Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
20	My company's safety policy can be best defined as "a performance-and-process-control oriented approach to safety and health management that gives organization sustainable competitive advantage in the marketplace by establishing a safe and healthy work environment that is conducive to consistent peak performance and that is improved continually."	2.23	Strategic Vision of Safety	9
30	"Obtaining customer/ client satisfaction" is a major objective of my organization's safety improvement program.	2.26	Strategic Approach to Safety Improvement	10
31	Training currently emphasizes: data gathering & analysis.	2.28	Strategic Approach to Safety Improvement	11
32	"Pressure from competitors" was a key factor that provided the motivation to start the safety improvement program.	2.33	Strategic Approach to Safety Improvement	12
62	There is an anonymous way for employees to make safety improvement suggestions. e.g. drop box	2.34	Employee Involvement and Empowerment	13
33	Steps taken in implementing my organization's safety improvement program include: "Benchmarks for improvement have been defined".	2.38	Strategic Approach to Safety Improvement	14
79	Decisions are supported by all in my organization.	2.42	Readiness to Embrace TSM	15

Table 4.49: Key TSM Impeding Indicators – All Constructs (continued)

S. No.	TSM Performance Indicator	Mean Response Score	Construct	Indicator Criticality Ranking
19	My company's safety policy can be best defined as "a set of processes developed to manage safety aspects of a project including encouraging, measuring and rewarding behavior that creates a safe working environment rather than catching people who break the rules."	2.44	Strategic Vision of Safety	16
34	"Environmental issues/considerations" was a key factor that provided the motivation to start the safety improvement program.	2.49	Strategic Approach to Safety Improvement	17

Further assessment of Tables 4.41-4.45 – to identify construct criticality ranking (based on a value of weighted mean response score for each construct) – results in Table 4.50. Table 4.50 has been arranged in descending order of construct criticality, and also provide construct criticality ranking and criticality zone.

Table 4.50: Construct Criticality Ranking & Zone

Construct	Weighted Mean Response Score (Scale 1-5)	Criticality Ranking	Criticality Zone
Strategic Vision of Safety	2.66	1	Moderate High
Strategic Approach to Safety Improvement	2.82	2	Moderate High
Employee Involvement & Empowerment	2.92	3	Moderate High
Readiness to Embrace TSM	3.18	4	Moderate Low
Knowledge of TSM	3.43	5	Moderate Low

The major TSM impeding indicators (with an indicator criticality index = 5 or 6) constitute 17 out of a total of 124 indicators i.e. 13.71%. The moderate TSM impeding indicators (with an indicator criticality index = 3 or 4) constitute 87 out of a total of 124 indicators i.e. 70.16%. Minor TSM impeding indicators (with an indicator criticality index = 1 or 2) constitute 19 out of a total of 124 indicators i.e. 15.32%. The remaining 1 indicator (0.09%) is not perceived by the industry as an inhibiting measure towards TSM adoption and implementation.

Strategic vision of safety, strategic approach to safety improvement, employee involvement and empowerment, and organizations' readiness to embrace TSM are all important components of a strategic total safety environment. Lack of performance of organizations in these areas undoubtedly indicates that contracting firms are not performing well in terms of achieving strategic safety improvement in the construction industry. Hence it can be concluded that the strategies currently adopted by construction organizations are not generally instrumental in nurturing safety as a total management process in their organizations (in order to strategically improve safety in the construction industry).

4.5 Conclusion

This chapter discussed phase I of the data analysis, which was undertaken to achieve objective 1 of the study, i.e. to establish the need for addressing safety as a total management process in construction contracting organizations in order to achieve the goal of zero accidents. Four (4) safety key areas of concern were identified and researched as part of data collection process. Descriptive analysis was performed to reach key conclusions. It was found that construction organizations generally lack in the following areas of safety performance at the various levels of the organization (Table 4.51):

Table 4.51: Ares of Safety Performance at the various Levels of the Organization

Organizational/ Performance Level	Key Non-Performance Areas
Strategic	1. Strategic vision of safety 2. Strategic approach to safety improvement 3. Employee involvement and empowerment 4. Readiness to embrace Total Safety Management
Management	1. Safety communication and decision making 2. Management commitment and support 3. Accident investigation and reporting 4. Safety training and orientation
Supervisory	1. Worker motivation 2. Safety commitment and support 3. Safety communication 4. Maintaining a positive attitude towards safety 5. Safety training and orientation

In addition, it is also concluded that OSHA is not performing at par in terms of achieving strategic safety improvement in the construction industry and needs to improve on its vision and approach in order to strategically improve safety in the industry. OSHA's strategic approach, as reflected from the findings, should be "continuous improvement through positive reinforcement" as against "inspection and penalty" approach. OSHA needs to work with the companies and not against them in order to achieve the strategic goal of zero accidents in the industry.

Based on the above findings, it can be concluded that construction industry (construction organizations and enforcement agencies) is not performing well in terms of strategically approaching safety. Hence there is a dire need for a framework that would allow the industry to strategically and continuously improve safety so as to attain and sustain the goal of zero accidents. Such a framework would be instrumental in generating a total safety environment in the industry, which would promote safety for the sake of safety and not for the safe of “compliance” or “penalty avoidance”. This framework would require an integral approach to safety with commitment and participation from all levels as well as sectors of the industry. The next chapter discusses the development of such a strategic framework for continuous safety improvement in the industry.

CHAPTER 5

DATA ANALYSIS PHASE II

5.1 Introduction

Phase I of the data analysis process (discussed in chapter 4) concluded that the construction industry lacks a strategic focus towards safety and hence established the need of a strategic safety improvement framework for the construction industry. As discussed later in this chapter, it is hypothesized that this strategic safety improvement framework should be based on an integral approach to safety that allows approaching safety as a total organizational process. This chapter discusses phase II of the data analysis process, which was undertaken to achieve objective 2 of the study, i.e. to identify the factors (latent variables/ constructs) determining the total safety environment of a construction contracting organization, which are most suitable and appropriate for measurement and improvement and hence play a pivotal role in achieving and sustaining the goal of zero accidents.

This phase of data analysis begins by presenting and critically discussing the integral approach to safety as adopted by this research. This discussion highlights the highest level of the hierarchy that decomposes total safety into four principal dimensions, viz., person, culture, behavior and process. Section 5.3 provides this discussion.

Defining the interior as well as exterior pursuits to safety is a complex task. The study endeavors to decompose safety dimensions into measurable attributes using a multiattribute analysis technique pioneered by Miller (1970) and used by researchers in similar research (e.g. Molenaar et al., 2009) The study briefly describes the multiattribute hierarchy used to measure total safety, which was defined through exhaustive literature review and expert interviews on the basis of which the four principal dimensions of total safety (safety categories) were divided into 22 subcategories, and were finally decomposed into 83 measurable safety characteristics that formed the basis of a questionnaire to measure total safety. This multiattribute analysis is discussed in sec. 5.4.

Following this, the study attempts to reach a consensus as to the selection of safe work behavior, which will be utilized as a measure of a company's safety performance for the study. This is done in section 5.5.

Using 686 questionnaire responses from construction companies with above average safety records, statistical relationships between total safety dimensions and safety performance (measured by safe work behavior) are revealed through a series of six latent variables (factors) that describe the total safety environment of a construction organization. This was achieved using confirmatory factor analysis (CFA) which reduced the attribute space from a larger number of sub-categories (22) to a smaller number of underlying dimensions/ factors (6). This combination of variables, in this case, aspects of safety dimensions, provided a way to simplify subsequent analysis (Hamilton 1992; SPSS 2001). A principal factor analysis (PFA) using the varimax rotation method with Kaiser normalization was utilized for the same. The survey development, administration and validation process is discussed in detail in the sections 5.6 - 5.8. The confirmatory factor analysis is detailed in section 5.9.

The data collected from this phase of the research forms the basis of a strategic safety improvement model for the construction industry, the development and utility of which is discussed in the next chapter.

5.2 Research Hypothesis Revisited

As mentioned earlier, it is the premise of this research that individual intentions, commitments, group culture, and work behaviors have as much, or more, to do with the safety performance than the safety management system. Based on the findings of phase I of the data analysis process (chapter 4) and extensive literature review, this research develops itself on an integral approach to safety (as explained in section 5.3) that collectively define the interior and exterior pursuits necessary to determine the true total safety environment of a construction organization. It is hypothesized that all safety dimensions offer complementary, rather than contradictory, perspectives. Hence an integral view of construction safety can only be achieved if integration is made of these areas of knowledge through an acknowledgement of them as the fundamental dimensions of safety. It is further hypothesized that all four pursuits by their very nature cultivate successful safety performance. While these hypotheses seem intuitive, little research has been conducted to specifically identify and measure critical characteristics as related to all the dimensions that, in integration, define as well as influence total safety. This is the core objective of this research.

5.3 An Integral Model for Safety

Ken Wilber (Wikipedia, 2011) defines four dimensions for every entity. Each entity or unit of reality that is both a whole and a part of a larger whole, has an interior and an exterior. It also exists as an individual and (assuming more than one of these entities exists) as a collective. Observing the entity from the outside constitutes an exterior (objective) perspective on that entity. Observing it from the inside is the interior (subjective) perspective, and so forth. If these four perspectives are mapped into quadrants, these constitute four quadrants, or dimensions.

The above concept leads to defining four dimensions of construction safety with respect to a construction worker as an entity (Figure 5.1): 1) Behavioral i.e. exterior individual (or, in the diagram, the upper-right) quadrant; 2) Intentional i.e. interior individual (upper-left) perspective; 3) Cultural i.e. interior collective (lower-left) dimension; and 4) Process i.e. exterior collective (lower-right) quadrant.

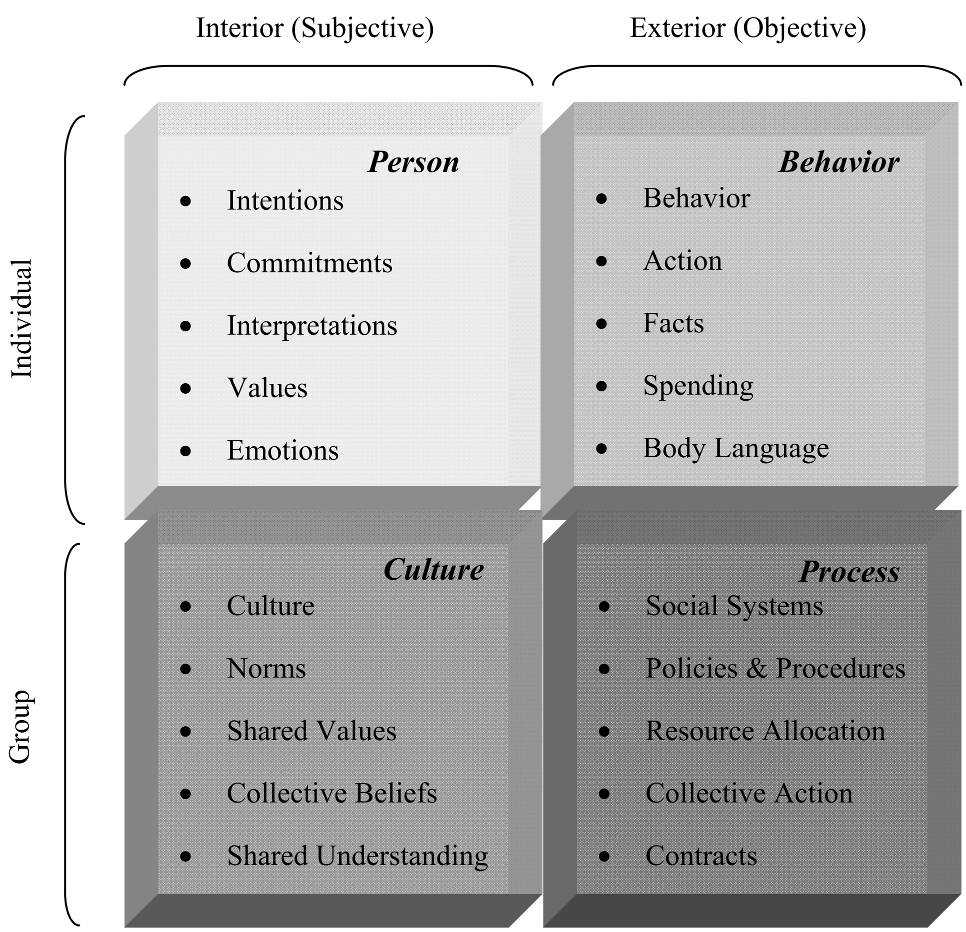

Figure 5.1: Integral Model for Safety (adapted from the work of Ken Wilber)

All four pursuits – intentional, cultural, behavioral and process – offer complementary, rather than contradictory, perspectives. It is possible for all to be correct and necessary for a complete account of human existence. Also, each by itself offers only a partial view of reality. Further, according to Wilber, these four perspectives are equally valid at all levels of existence. Hence an integral view of construction safety can be achieved if integration is made of these four areas of knowledge through an acknowledgement of them as the four fundamental dimensions of safety.

Note that the right sides of the quadrants are concerned with empirical observation—what does it do? The left sides of the quadrants focus on interpretation—what does it mean?

This integral approach to safety provides a more complete view of reality. It allows a study of what drives safety performance, highlights the importance of the human side of safety and hence provides a mechanism to achieve incident and injury free environment. A major intent of viewing safety from the integral perspective is that it provides the capability with intentionally viewing from all aspects so that a complete and comprehensive view of safety can be achieved that enables quality decision making and actions. This integral approach to safety forms the basis of this research.

Traditionally, organizations tend to implement change through systems – a process approach to safety, or by improving workers' behaviors – a behavior based approach to safety. They focus on measures to control hazards (via systems), and means to control workers' behaviors so that they comply with prescribed safe practices. This approach emphasizes (1) organizational policies, systems and procedures to prevent unsafe conditions and (2) workers' training and motivation to prevent unsafe behaviors. Safety programs – such as subcontractor selection, training, inspections, motivation, enforcement, etc., as well as efforts towards behavior-based safety aim at increasing the workers' compliance with prescribed 'safety rules' and 'safe behaviors.' This approach has resulted in significant improvements, but has still not succeeded in achieving the zero-accident goal. The reasons are intuitive as identified below.

While the traditional application of this "exterior" approach to safety aims at creating safe work behaviors, it ignores how the interior characteristics of the individual and the organizations influence the work behaviors and affect the possibility of errors and accidents. On one hand, it does not account for the personal factors that collectively define a worker's intention for safety such as, level of self-commitment, interpretation of being safe, the perceived value of safety, the natural tendency for least effort, and the individual response under production and economic pressures for efficiency. On the other hand, the approach does not account for the cultural factors that shape the work environment such as, the team values, beliefs, norms, practices, and collective response under production and economic pressures for efficiency. These factors generate the situations the workers face, and the individual as well as crew's ability to cope with these situations (Mitropoulos et al., 2009).

From a practical perspective, a key concern is that at the work level, there is a continuous tension between safety and production or costs; in the short term, such conflicts are usually resolved in favor of production, because production efforts have relatively certain outcomes and receive rapid and rewarding feedback (Reason 1990). A recent study of safety on international projects (Mahalingam and Levitt 2007) also illustrated that economic pressures were stronger determinants of work behavior than the safety systems.

As a result of these “interior” characteristics, efforts to improve safety through objective assessments and advancements (new methods/ improved safety features and controlled behaviors) tend to be ineffective because the behavior change is only temporary and is not usually sustainable (Mitropoulos et al., 2009). The current safety strategies in construction, which are largely oriented towards systems advancements and behavior control, hence prove to be inadequate to achieve the zero-accident goal because of this fundamental flaw in their approach.

The key challenge for researchers and practitioners is to develop total safety systems that are simultaneously highly productive and highly reliable and can function effectively in the dynamic, complex, and competitive conditions that construction projects face. This requires a treatment of safety from an integral perspective taking into consideration all four dimensions of safety and their inter-dependence. This treatment will allow a fundamental understanding of the individual and organizational characteristics that govern both the safe behaviors of workers and the effectiveness of safety systems, and will aid in determining the underlying factors that control the true total safety performance of a company.

5.4 Multiattribute Heirarchy

Employing multiattribute analysis, the problem of approaching safety as an integral perspective can be decomposed into three interdependent sets of factors – person, culture and process, defining total safety and one set of factor – behavior, defining safety performance. Person is integral to defining, for a worker, the interior characteristics such as intentions, commitments, interpretations, values and emotions, as well as the exterior characteristics such as actions, behaviors, body language and the like. The second category, culture, is integral to defining, for an organization, the interior characteristics of a corporation such as norms, shared values, collective beliefs, and shared understanding. The third category, process, is integral to defining the exterior organizational (group) characteristics such as collective actions, social interactions, safety systems and the like. A good safety process is necessary for a company to properly communicate its safety goals. The major subcategories for each of these three categories are defined in the following sub-sections. Note that the fourth principal safety dimension – behavior, which has been selected as the safety performance measure for this study, is discussed in section 5.5.

5.4.1. Person

5.4.1.1. Intention

A person's intention in performing an action is his or her specific purpose in doing so, the end or goal that is aimed at, or intended to accomplish. By setting an intention, one makes it clear to oneself and others, just what one plans to do. Lacking intention, one sometimes strays without meaning or direction. When one sets a positive intention and then acts on it to demonstrate commitment (such as before entering the workplace, one can intend to learn something new or be helpful), this has a positive impact not only one one's own behavior but also on the behavior of surrounding team members. Intention can also give fortitude for dealing with tough times. For instance, with all the challenges construction sites generally offer, if one's intention is to live through this process each day with health and safety, this intention would help maintain composure, sanity, and on a good day, a sense of humor.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.2. Commitment

Worker commitment to safety is a central element of incident and injury free environment. This commitment reflects the interactions of a worker with people and environment dominated by one’s obligations. Individual commitment includes personal commitment, which is often a pledge or promise to ones' self for personal growth and preferences, and commitment as a member of an organization, which is often a reflection of the expectations of top management as communicated to and perceived by the worker. This commitment may or may not be explicitly stated, although an explicit statement of individual commitment to safety brings its own advantages. Explicit commitment has the obvious advantage of accountability. Making a voluntary public commitment to safety not only increases the likelihood of the person making the commitment to follow through with it but also gives the right to fellow team members to explicitly remind to that person at some point in time if the person is not fulfilling what he/ she committed. Strategically, this would help generate an environment where commitment would not be something temporary but would rather be everlasting in that everyone would want (and not required) to live up to their voluntary commitment. It is also important to note here that periodic renewal of commitment is also important to sustain an environment fostering commitment. When people genuinely make a commitment and mean it when they make it, they continue to live up to that commitment. What happens usually is that over the years, people do not renew their commitments and hence may need to be reminded again.

The importance of obtaining worker commitment to safety for achieving and consistently maintaining incidence and injury free environment cannot be overemphasized. When employees are personally committed to safety, they are more willing to cooperate among each other as well as with the management to continuously improve the safety performance. Although 100% commitment from all employees is not a must to reach the goal of incident and injury free, it would be a lot easier if this could be achieved. The minimum needed is a level of commitment from the workers that when they see a fellow worker putting himself/ herself at risk, they would go and talk to that person to make sure that the person gets the appropriate help and does not get injured.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.3. Value

A personal value is an absolute or relative ethical value, the assumption of which can be the basis for ethical action. Value is the foundation upon which measures of integrity are based. Values tell people what is good, beneficial, important, useful, beautiful, desirable, constructive, etc. They answer the question of why people do what they do. A value is not something one merely knows about or has observed in others that lacks guiding influence in one’s life. Values are those principles that are so ingrained in one’s personality that they become the determinants of how one thinks, acts, and finally what one says and how one says it.

Values can be defined as broad preferences concerning appropriate courses of action or outcomes. As such, values reflect a person's sense of right and wrong or what "ought" to be. Values tend to influence attitudes and behavior. For example, if a person values safety and goes to work for an organization that demonstrates evident lack of commitment to workers' safety, that very person may form the attitude that the company is an insecure place to work; consequently, he or she may not produce well or may perhaps leave the company. It is likely that if the company had had a stronger demonstrated commitment to safety, the attitude and behaviors would have been more positive.

Everyone develops a set of values, as they become adults. These values are what everyone looks to for guidance in the decisions they make in life – decisions in the home, in the family, in relationships, in friendships, and in our occupations and business.

Values in the human personality have basically one of three aspects: moral values, neutral values, and immoral values. A moral value is a principle that one lives by. A moral value is an absolute. It is not negotiable. Other values, such a neutral values, are less important, like obtaining a good product when one purchases something. The realm of immoral values is that need to be examined, such as common temptations to a person. Immoral values are not always based on ethical standards, but may be of a questionable source or may not be concerned with fairness, honesty, or integrity.

The key question is: In which realm are one's safety values? Safety values in the neutral realm include a situation where one knows about safety and can work safe if one wants to, but for some reason (e.g. production pressures) one chooses to ignore safe work procedures because they are not convenient. If one is lucky, one may not be injured in this realm. But in thinking about noncompliant safety practices one has to recognize that taking unnecessary risks is a poor example to others, especially when a less experienced individual copies your work approach and is injured. In this way, as far as safety is concerned, operating in a neutral realm is borderline immoral because one at least contributes to an Injury of another person if not of oneself.

Safety values in the immoral realm are seen in those who purposely work recklessly and give no regard to safe work procedures and resist good safety practices. It is both the neutral and the immoral safety values that need to be eliminated.

If one takes a moral approach to managing safety, it then becomes one's personal value. In such a case, one's safety values provide guidance in one's actions so that the person and those around him or her are safer by the very influence of one's personal safety values. If this is true then one's safety values are in the moral realm.

The researcher would like to take the position that although the value system for a person might fall in the neutral or immoral realm, there is still a common denominator for all: nobody would want to get hurt; everyone would like to go home each and every night with no injury.

For achieving incident and injury free environment, safety cannot be a priority; it must be a value. The reason is simple: priorities change, while values don't. For instance, on a project with safety as a top priority, production pressures might lead to tighter schedules and suddenly safety may no longer be at the top of priority list. In order to increase productivity, unsafe acts and behaviors may become suddenly acceptable (rather desirable) and since increased productivity would most probably lead to increased cost while the pressure of maintaining a minimum quality is still on, safety suddenly drops to the very bottom of the priority list. This is why safety must be a personal value if incident and injury free environment is to be achieved as well as sustained. In fact, safety needs to be such a highly held personal value that one doesn't even think about it while one is prioritizing one's activities.

Two (2) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.4. Attitudes

Attitudes are a direct reflection of a person's character traits. These may be attributed to intentions (the specific purpose of doing what the person is doing) and emotions (the state of mind). Cox and Cox (1991) argue that employees' attitudes toward safety are one of the most important indices of safety performance. These attitudes may be positive, negative or often in between, depending on the situation. Positive attitudes lead to safe behaviors, while negative attitudes can lead to unsafe behaviors or risk exposure. Most of these attitudes are established through training, while others are gained from peer groups. Individuals differ in their attitudes and hence their behaviors.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.5. Perception

Perception is the process of attaining awareness or understanding. Perceptions vary from person to person. Different people perceive different things about the same situation. But more than that, they assign different meanings (interpretations) to what they perceive. Perceptions (and their interpretations) may change over time. Perceptions may be positive, negative or often in between, depending on the situation. Positive perceptions lead to positive interpretations and hence safe and healthy behaviors, while negative perceptions can lead to misinterpretations and hence unhealthy and unsafe behaviors and/ or risk exposures. Perceptions are usually driven by personal experience and training. Individuals differ in their perceptions and hence their behaviors.

Personal risk perception has been found to be closely associated with attitudes toward safety (Rundmo 1997). Individuals, however, differ in their perception of risk and willingness to take risks, as demonstrated by March and Shapira (1992). Also, perceptions inherently lead to interpretations or misinterpretations. Interpretation refers to a particular view or explanation, as of the environment, procedures, performance, events, etc., provided by the use of personal experience, etc. It also refers to the conception of another person's behavior. Results of interpretations lead to specific emotions (such as happiness, anger, anxiety, etc.) and hence behaviors. Misinterpretation usually leads to unhealthy and unsafe (negative) emotions and hence behaviors. That is, when one has a positive perception and then acts on it to demonstrate the same (such as one can have a better perception of risk in terms of low willingness to take risk), this has a positive impact not only one one's own behavior but also on the behavior of surrounding team members because it is interpreted as such.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.6. Interpretation

Interpretation refers to a particular view or explanation, as of the environment, procedures, performance, events, etc., provided by the use of personal experience, etc. It also refers to the conception of another person's behavior.

Results of interpretations lead to specific emotions (such as happiness, anger, anxiety, etc.). Misinterpretation usually leads to unhealthy (negative) emotions.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.7. Emotion

Emotion is the complex psycho-physiological experience of an individual's state of mind as interacting with biochemical (internal) and environmental (external) influences. Emotion is associated with mood, temperament, personality and disposition, and motivation.

Results of emotions are principally behaviors and emotional expressions. People often behave in certain ways as a direct result of their emotional state. For instance, in case of a safety emergency (such as fire), the emotional expressions and behaviors of people might be anxiety, anger, fear, loneliness, sadness, disappointment, or depression. Emergency emotions are typically negative responses. Unless adequately regulated, emergency emotions are often a source of suffering.

Right or wrong, one’s mind automatically attaches emotional meaning to events. If the level of emotions “fit” the situation, a proportionate response will likely follow and things will run smoothly. However, over or under responses usually lead to some form of negative impact on overall levels of happiness and relationships with others.

For example, if a supervisor happens to mention safety as a major concern repeatedly in his or her conversation with a worker, the worker will react according to his or her own interpretation. The interpretation that the supervisor “cares about my safety” may cause a feeling of security, while an interpretation that the supervisor is “over-emphasizing safety" may cause anxiety or anger. If feeling secured, the worker may continue with the conversation while actively participating. If anxious, the worker may stop talking and search for a quick exit. If angry, the worker might criticize the supervisor and/or wait to point out a flaw of his/ her. In reality, the supervisor might actually care about safety of workers.

As workers pass through various stages of their work lives, they are exposed to many experiences: some are positive (e.g., awards, appreciations, recognitions, accomplishments) and others are negative (e.g., injuries, illnesses, accidents). Organizations are one of the best sources of support during stressful times. A major way that organization members support each other is through the appropriate expression of emotions.

In order for organization members to respond to one another with appropriate emotions, it is very important to be involved in each other's work lives (and personal lives to some extent). This requires an effort on the part of each team member to be concerned with how the others are doing, whether physically, emotionally, or spiritually. For example, members should be observant to how their fellow workers are approaching safety in terms of their actions and behaviors, and when they see a fellow worker putting himself/ herself at risk, they would go and talk to that person to make sure that the person gets the appropriate help and does not get injured. Members who are tuned in to what is going on in each other's work lives will be able to respond more quickly and more appropriately.

In healthy organizations, members make a special point of listening to what others in the team have to say, whether they be subordinates or supervisors. Sometimes one may not be able to fully understand why another person is experiencing a certain emotion, such as anger or sadness. However, by asking questions and carefully listening, one can gain a better understanding of the other person's feelings, and can thus respond in a more helpful way.

Empathy, which is the ability to experience as one's own the feelings of another, is a major asset in being able to respond with appropriate emotions for a given situation. For example, a supervisor who is able to take the perspective of a worker who has just been injured will be better equipped to respond emotionally to him or her than someone who is very disconnected. By putting oneself in another member's shoes, one will be a better source of strength and encouragement in both positive and negative situations.

While anger is a common emotion, if not kept under control it can lead to many problems, including conflict, and other serious issues. When one becomes angry over a particular incident, it is very important that the person takes some time to think about the situation before acting. In healthy organizations, individual members express their anger in a calm, constructive, and assertive manner.

Being able to respond to other team members with a wide range of emotions, appropriate for each situation, is a key to successful organizational functioning. Persons who become proficient in this area are better equipped to build strong relationships and to deal with stressful work events as they occur.

Two (2) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.1.8. Proficiency

Proficiency is the ability of an individual to perform a job properly. Proficiency can be seen as a combination of knowledge, qualifications, skills and behavior used to improve performance; or as the state or quality of being adequately or well qualified, having the ability to perform a specific role. Proficiency is sometimes thought of as being shown in action in a situation and context that might be different the next time a person has to act. In emergencies, competent people may react to a situation following behaviors they have previously found to succeed. To be competent a person would need to be able to interpret the situation in the context and to have a repertoire of possible actions to take and have trained in the possible actions in the repertoire. Regardless of training, proficiency would grow through experience and the extent of an individual to learn and adapt.

Proficiency is a major factor influencing safety levels (Simon and Piquard 1991; Jaselskis et al., 1996; Mohamed, 2002). For achieving incident and injury free environment, workers must have the confidence that they have the necessary knowledge, skills and experience to perform a particular job safely. When employees have confidence in their proficiency, they have more positive attitudes towards safety and are more willing to cooperate among each other as well as with the management to continuously improve the safety performance.

Seven (7) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2. Culture

It is easy to recognize that there are intrinsic differences among organizations in how people interact and the values that are reflected in their work. In every organization, there are "right ways" to do things – organizational norms. Because these characteristics influence the way things get done in an organization, it is reasonable to assume they have an impact on safety.

Corporate culture is instrumental in an organization's success. It provides the workplace environment for the employees of an organization. When people work in an environment that they perceive as rewarding, they are more likely to perform more safely and more productively.

The definition of corporate culture is complex when all of the facets above are considered. For purposes of this study, corporate culture is defined as the *norms, shared values, collective beliefs, and shared understandings that are consistent throughout all members of the corporation*. These norms, values, beliefs and understandings must be consistent throughout upper management, middle management, and field employees.

5.4.2.1. Management Commitment & Involvement

This section measures the level to which management acknowledges the significance of safety and becomes involved in it. The role management plays in promoting safety cannot be overemphasized. Management both creates and controls the environment in which construction accidents occur (Smallwood 1996). Management's commitment is a central element of the safety environment (Zohar 1980). Management's role has to go beyond organizing and providing safety policies and working instructions. Several studies show that the management's commitment and involvement in safety is the factor of most importance for a satisfactory safety level (Jaselskis et al. 1996). Langford et al. (2000) found that when employees believe that the management cares about their personal safety, they are more willing to cooperate to improve safety performance. Management safety commitment and involvement provide the strategic environment conducive to achieving and sustaining incident and injury free.

Seven (7) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.2. Workers' Commitment & Involvement

Workers in field operations can benefit the most from safe conditions. This section measures workers' commitment to safety and involvement in it. Anecdotal evidence suggests that it is not just management participation and involvement in safety activities that is important, but the extent to which management encourages the involvement of the workforce (Niskanen 1994). Moreover, management must be willing to devolve some decision-making power to the workforce by allowing them to become actively involved in developing safety policies, rather than simply playing the more passive role of the recipient (Williamson et al. 1997). Workers' involvement includes such issues as procedures for reporting injuries and potentially hazardous situations. Workers' safety commitment and involvement provide the work environment conducive to achieving and sustaining incident and injury free.

Five (5) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.3. Supervisory Commitment and Involvement

A successful safety management system is based on the premise that safety is both a management responsibility and a line function. While managers help develop and implement the program, its actual success depends upon the ability of supervisory personnel to ensure that the program is carried out during daily operations (Agrilla 1999). Langford et al. (2000) indicate that the more relationship-oriented supervisors are, the more likely it is that operatives will perform safely. This section measures supervisory commitment to safety and their involvement in it. Supervisory support in terms of coaching, mentoring and training workers, providing them with the right equipment at the right time, caring for their personal safety, demonstrated commitment to safety, empowering workers to actively participate in highlighting unsafe conditions and proposing solutions, motivating workers, etc., is a key element in developing a safe work environment conducive to incident and injury free.

Seven (7) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.4. Subcontractor Commitment & Involvement

Subcontractors are often an integral part of construction projects and can have a direct bearing on company safety. This section measures subcontractors' involvement in the process and their commitment to safety. Subcontractor involvement in terms of attending safety meetings, orienting and training their employees for safety, providing their employees with the right equipment at the right time, caring for their employees' personal safety, encouraging their workers to actively participate in highlighting unsafe conditions and proposing solutions, etc. is a key element in developing a safe work environment conducive to incident and injury free.

Seven (7) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.5. Communication

Management is expected to use a variety of formal and informal means of communication to promote and communicate its commitment to safety (Baxendale and Jones 2000). Simon and Piquard (1991) suggests that both management communication and employee feedback are critical for suggesting safety improvements and reporting near misses as well as unsafe conditions and practices.

Four (4) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.6. Work Environment

Work environment refers to the degree of trust and support within a group of workers, confidence that people have in working relationships with coworkers, and the general morale. Having a supportive work environment demonstrates workers' concern for safety and fosters closer ties between them. Coworkers' attitude toward safety has been widely included in safety climate studies (Goldberg et al. 1991). These attitudes include helping team members stay safe and keep away from unsafe acts, etc.

Five (5) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.2.7. Production Pressure

This section deals with the degree to which employees feel under pressure to complete work, and the amount of time to plan and carry out work (Glendon et al. 1994). Ahmed et al. (1999) identify the tight construction schedule as the most serious factor that adversely affects the implementation of construction site safety in Hong Kong. This is supported by another study (Sawacha et al. 1999), which found that productivity bonus pay could lead workers to achieve higher production through performing unsafely. Langford et al. (2000) state that supervisors are likely to turn a blind eye to unsafe practices on a site due to the pressure to achieve targets set by agreed-upon programs. They also argue that such ingrained practices of the industry (i.e., valuing expediency over safety) have to be overcome in order for safety management to be effective.

Seven (7) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3. Process

5.4.3.1. Safety Rules and Procedures

Management commitment to safe and healthy job sites is critical. The most significant evidence of management commitment towards safety is a written comprehensive safety and health program. Rules and procedures are the core component of safety management programs. Several studies show that presence of a comprehensive safety program is the most important factor for a satisfactory safety level (Jaselskis et al. 1996; Langford et al. 2000). A good health and safety program that is effectively implanted can save money in a number of different ways including, holding down insurance costs, reducing costly litigation, reducing disability claims, increasing productivity of employees, leading to more contracts (good reputation), reducing the number of compliance inspections and associated penalties. The program forces the construction companies to put their commitment to safety and health in writing; to establish policies and set goals for safety and health; and to communicate effectively the safety policies, procedures, and goals. Companies without a safety and health program experience 30% more accidents than those with the programs (Goetsch, 2011). A major factor influencing the safety level is the extent to which workers perceive safety rules and procedures as promoted and implemented by the organization (Cox and Cheyne 2000). Hood (1994) states that problems related to safety can frequently be traced to inconsistently applied or nonexistent operating procedures.

Five (5) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3.2. Site Layout Planning

The aim in site layout planning and facilities is to produce a working environment that will maximize efficiency and minimize risks (Gibb and Knobbs 1995). Aspects of site layout planning that need to be addressed include access and traffic routes, material and storage handling, site offices and amenities, the construction plant, fabrication workshops, services and facilities, and the site enclosure (Anumba and Bishop 1997). Previous research shows that tidy and well planned (layout) sites are more likely to provide a high level of safety performance (Sawacha et al. 1999). For the purpose of this study, workplace hazards were defined as tangible factors that may pose risks for possible injuries or ailments. Within this definition, hazards do not always result in accidents, but they lurk in work environments, waiting for the right combination of circumstances to come together.

Four (4) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3.3. Safety Training and Education

Safety training and education are integral to teaching safe attitudes and to providing feedback on the effectiveness of current safety procedures. This section measures the level and effectiveness of the safety training in terms of developing and sustaining a work environment conducive to incident and injury free. Safety training is a major component of jobsite safety. Safety in essence is a team process and continuous teaching and learning at all levels is of utmost importance in order to not only keep oneself on track on safety but also to sustain a collaborative safe environment on all job sites. As is true in most settings, the learning process is never completed. As time goes by and as jobsite conditions change, it is necessary to provide additional training to workers. This training tends to be focused on the needs of individual field workers. On site specific training can provide positive reinforcement; the workers can be informed what deficiency of safety practices require improving and rectifying immediately. Prior research indicates that safety training can modify worker safe behavior; the workers can understand the work potential hazard such that they can prevent it (Hallowell and Gambatese, 2009).

Four (4) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3.4. Accident Investigation and Reporting

This section measures the level of effectiveness of the accident investigation and reporting system in terms of developing a work environment conducive to incident and injury free. The approach to accident investigation can be the difference between safe and unsafe behaviors. A no-blame approach to accident investigation (investigating the cause of the accident and not the person responsible) would facilitate in instilling positive safety behaviors in workers. This approach further helps in isolating and pinpointing the cause of the accident. This information can then be used to prevent future accidents, which should be the primary purpose of accident investigation. This approach and importance of accident investigation has been attested by the following from the Society of Manufacturing Engineers: The primary reason for investigating an accident is not to identify a scapegoat, but to determine the cause of the accident. The investigation concentrates on gathering factual information about the details that led to the accident. If investigations are conducted properly, there is the added benefit of uncovering problems that did not directly lead to the accident. This information benefits the ongoing effort of reducing the likelihood of accidents. As problems are revealed during investigation, action items and improvements that can prevent similar accidents from happening in the future will be easier to identify than at any (other) time. Hence an effective accident investigation and reporting system can provide continuous and sustainable improvement in safety.

Four (4) measurable safety characteristics (survey items) were used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3.5. Safety Incentive Mechanisms

Safety incentives are defined as any gifts or rewards that are given out on a regular basis. This can be a variety of rewards from points to earn company merchandise to actual cash or cash equivalents. This section measures the company's use of incentives to improve safety performance.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

5.4.3.6. Safety Disincentive Mechanisms

A disincentive is any form of punishment. It can be anything from an oral reprimand, to a written reprimand, to garnishment of wages or termination of employment. This section measures the company's use of disincentives for unsafe behaviors to improve safety performance.

One (1) measurable safety characteristic (survey item) was used from this subcategory as part of the measure of total safety in a construction organization.

The three major categories defined above with their corresponding subcategories were altogether broken down into 83 measurable characteristics (questionnaire items) defining total safety. This is depicted in Table 5.1.

The next section (section 5.5) provides justification for the selection of safe work behavior as the safety performance indicator for the study.

Table 5.1: Number of Survey Items Pertaining to Safety Dimension Subcategories

Safety Dimension Subcategory	Survey Item(s)
Personal Intention & Commitment	2
Personal Value System	2
Personal Attitude & Perception	2
Personal Interpretation & Emotion	3
Personal Proficiency	7
Management Commitment & Involvement	7
Workers' Commitment & Involvement	5
Supervisory Commitment and Involvement	7
Subcontractor Commitment & Involvement	3
Communication	4
Work Environment	5
Safety Accountability	2
Production Pressure	7
Cultural Norms	3
Shared Values	3
Collective Beliefs/ Shared Understanding	2
Safety Rules and Procedures	5
Site Layout Planning	4
Safety Training and Education	4
Accident Investigation and Reporting	4
Safety Incentive Mechanisms	1
Safety Disincentive Mechanisms	1
Total	83

5.5. Safe Work Behavior as Safety Performance Indicator

This study adopts safe work behaviors (observable actions) as the safety performance indicator. The justification for the selection of safe work behaviors as the variable measuring safety performance for construction organizations follows. This justification is based on the premise that leading indicators are better measures of safety performance than lagging indicators.

Traditionally, safety performance has been measured by such metrics as the Occupational Safety and Health Administration (OSHA) recordable injury rate (RIR); or the experience modification rating (EMR) on workers' compensation. These have served the purpose of providing information by which contractors could assess their safety performance in terms of construction industry averages on those metrics or to make comparisons with other firms. These have also been used widely by OSHA, insurance companies, facility owners, and other parties involved in the construction industry.

These traditional measures if safety are after-the-fact measures; namely, that safety is measured after injuries have already occurred. These metrics provide historical information about some aspect of the safety performance that has occurred and rely primarily on some form of accident or injury data. These measures are labeled reactive, trailing, downstream, or lagging indicators because they rely on retrospective data. Focusing on these measures (e.g., accident rates and compensation costs) often means that the success of safety is measured by the levels of system failure (Cohen 2002). While lagging measurements can provide data about incidents after-the-fact, the question remains regarding the value of these metrics as a means of predicting workplace safety performance. Grabowski et al. (2007) note that a growing number of safety professionals question the value of lagging indicators and argue that lagging indicators do not provide sufficient information or insight to effectively avoid future accidents. Mengolini & Debarberis (2008) support this position stating that past performance is a poor predictor of future results. Glendon and Mckenna (1995) identify a number of reasons why accident data, or similar outcome data, are poor safety indicators. The main problems are that such data are insufficiently sensitive, of dubious accuracy, retrospective, and they ignore risk exposure. Although accident statistics are widely used throughout the construction industry, Laitinen et al. (1999) state that it is almost impossible to use accidents as a safety indicator for a single construction site. This is because of random variation, where many sites will have no accidents, and it is not possible to determine whether these sites with zero accidents are safer than sites with four or five accidents.

Recognizing such shortcomings, many advocate a shift to using proactive, upstream, or leading indicators (Flin et al., 2000; Cooper, 2000; Mohamed, 2002; Choudhry and Fang, 2005; Hinze, 2005). In contrast, leading indicators are measures which are not necessarily historical in nature but rather can be used as predictors of future safety performance. Toellner (2001) characterized leading indicators as measurements linked to actions taken to prevent accidents. Grabowski et al. (2007) described leading indicators as conditions, events, or measures that precede an incident and has a predictive value in regards to an accident/incident/unsafe conditions. Hinze et al. (2010) characterize leading indicators of safety performance as consisting of a *set of selected measures that describe the level of effectiveness of the safety process*. Leading indicators measure the building blocks of the safety culture of a project or company. When one or more of these measures suggest that some aspect of the safety process is weak or weakening, interventions can be implemented to improve the safety process and, thereby positively impact the safety process before any negative occurrences (injuries) are sustained.

In view of the above reasons, this study adopts safe work behaviors (observable actions) as a leading indicator to measure safety performance. This is based on the premise that unsafe behavior is intrinsically linked to workplace accidents (Thompson et al. 1998). It is also supported by findings from studies and models developed based on the unsafe behavior concept (Smith and Arnold, 1991; Staley, 1996; Krause, 1997). It is noteworthy that more than 80% of all workplace accidents and incidents are attributed to unsafe behaviors (HSE, 2005).

Two (2) measurable safety characteristics (survey items) were used from this subcategory as a measure of safety performance in a construction organization. These have been adopted from previous research (Mohamed, 2002).

The survey development, administration and validation process is discussed in detail in the next three sections (sections 5.6 - 5.8).

5.6 Survey Development

A comprehensive literature review was performed to discover interior and exterior characteristics that influence safety. These characteristics were then organized into a hierarchical structure and decomposed into measurable charedacteristics using rigorous multiattribute techniques (Miller 1970), as previously discussed. A questionnaire was then developed from the multiattribute hierarchy through tested survey and attitude measurement procedures (Oppenheim 2001). All safety characteristics were measured through a five-point Likert-type response format. Items, relating to each of the dimensions, were used in the form of statements to measure individual dimensions under investigation. To the extent possible, the different statements used in developing the questionnaires were drawn upon scales that had been previously used by researchers (Cox and Cox 1991; Tomas and Oliver 1995; Glazner et al. 1999; Cox and Cheyne 2000; Lee and Harrison 2000, Mohamed, 2002). A limited number of statements, however, were slightly modified to reflect the nature of the construction industry. Participants were asked to endorse the statements using a five-point Likert-type scale (from 1=‘‘strongly disagree’’ to 5=‘‘strongly agree’’).

Subsequent to the development of the survey instrument, pilot surveys were conducted via face-to-face meetings with select professionals including short-listed experts from construction contracting organizations representing their top management, middle/ project management, supervisors, foremen and workers, all having expertise in or exposure to safety issues. The intent of these pilot surveys was to pretest the questionnaire on select professionals so as to obtain such version of the survey (after appropriate modification as and if needed) that would achieve acceptable levels of measurement reliability and validity. With input from these local industry professionals, the questionnaires were appropriately modified to best capture the information specific to research needs. The questionnaire contained, in its final form, a total of 85 statements (83 statements listed in Part I to measure safety and 2 statements listed in Part II to measure safety performance). A number of negatively worded statements were presented in the scale, as recommended in the measurement literature (Pedhazur and Schmelkin 1991).

5.7 Survey Administration

5.7.1. Method

A quantitative research method was chosen for the study, since it was exploratory in nature. A survey methodology was selected to collect data regarding the four dimensions of safety because it offered the best opportunity to capture a cross section of the beliefs, values, systems and behaviors in multiple companies in a timely and efficient manner. Data gathering is complex. So, the decision on which survey method to use depends on the particular research topic, characteristics of the sample, and availability of staff and resource (Fowler 1993). Assessing the methodologies for data collection against the objective of this phase of the research led to the determination that questionnaires send by electronic mail and postal mail with as-necessary follow-up telephone calls were the most suitable for this phase of research work. Because of the nature of structured interviews, it was determined that these would best be achieved by in-person interviews, However, because of geographic constraints many were done by telephone. For data gathering, telephone or facsimile correspondence were used only when the response to the questionnaire was behind scheduled due dates, or when the respondents contacted the researcher with questions or requests for further information.

An exhaustive list of industry contractors was prepared as a first step of survey administration. Various published and unpublished sources were used to develop a list of commercial construction contractors in the U.S. construction industry. This identification was done, in particular, from the following sources:

1. Engineering News Record (ENR) publications, including the list of Top 500 U.S. Contractors;
2. The general contractors list published by the Associated General Contractors (AGC) of America; and
3. A customized list of general contractors and subcontractors prepared from the yellow pages, trade magazines and other published and unpublished sources.

5.7.2. Data Sample

The theoretical population of this phase of research was the top management, senior project managers, safety managers/officers, supervisors, foremen, and construction workers of all general contracting firms as well as subcontracting firms in the United States. No limits on the size of construction firms or annual turnover of the construction firm were established. There were not a minimum number of years of experience an individual should have to qualify to be a participant. This population description is in line with the major objective of the research – developing a strategic safety improvement model for construction contracting (and subcontracting) firms in the United States based on an integral approach to safety.

The final data sample was selected by a combination of sampling methods. The researcher first used purposive sampling. In purposive sampling "the participants are hand-picked from the accessible population" (Gliner & Morgan, 2000). The participants were selected because of their experience as senior corporate and project managers for commercial construction firms. Firstly, the liaison of Florida International University (FIU) with the local construction industry was utilized for selecting appropriate construction companies. Secondly, since many of the government organization (counties and cities) employees are students at FIU Construction Management (CM), Civil and Environmental Engineering (CEE) and other engineering departments, these employees were approached first hand for their voluntary contribution in the research. Thirdly, the CM department at FIU also has an advisory committee made up of a number of large commercial construction contractors in the South Florida region. These advisory committee members were also approached first hand with the request to voluntarily contribute to the research.

Convenience sampling was also used to solicit participants for this phase of the research. In convenience sampling, "the participants are selected on the basis of convenience rather than chosen in a serious attempt to select participants who are representative of the theoretical population" (Gliner & Morgan, 2000). Senior managers working for companies in Florida to which the researcher had access were given the opportunity to volunteer for participation. In some cases the companies were known to the researcher and in other cases the companies were randomly selected from the three sources identified above.

Snowball sampling was also used. "Snowball sampling is a modification of convenience or accidental sampling …. People are asked for additional references" (Gliner & Morgan, 2000).

The major chunk of data was collected using random sampling. According to good survey practice (Tull and Hawkins, 1990), a letter was sent to the Chief Executive/Managing Director of companies randomly selected from the three sources of identification indicated above. This letter was sent to introduce the research and request voluntary input. Referred to in the letter was a request for names of the key personnel associated with safety management processes and safety decision making in the companies, who would subsequently be canvassed for opinions.

5.7.3. Delimitations

The focus was delimited to general contractors and specialty contractors with major experience in commercial building construction. In future studies, research may be expanded to other types of construction such as residential, heavy-civil, or industrial.

5.7.4. Survey Distribution and Response

The surveys were carried out over the period extending from August 2009 to March 2010. The questionnaires were posted to named individuals in the months of August-

December 2009, with a suggested date for return at the end of October 2009-February 2009. Questionnaire returns were received over the next few months, in some cases after a phone call reminder.

The final data sample included general contractors, structural steel contractors, poured concrete contractors, precast concrete contractors, masonry contractors, electrical contractors, mechanical and HVAC contractors, etc. representing 97 different companies (31 general contractors and 66 specialty contractors) working in the building construction sector (commercial and institutional). These 97 companies selected shared many common traits. They were mostly medium to large size firms on the basis of their employee counts and annual turnovers; they all performed all or some of their own work (such as carpentry, concrete placement, masonry work, etc.); they all primarily concentrate on large commercial buildings; and all were willing to actively take part in data collection.

It is worth mentioning here that 69 of the 97 (71%) companies which responded to the survey were the same as for surveys conducted in phase I of the research (chapter 5). Thus good consistency of data was maintained through the two phases of the research.

Over 2200 questionnaires were distributed to the companies. A total of 723 questionnaires were returned. However, 37 questionnaires were either determined to be outliers or were discarded owing to possibility of bias. A total of 686 questionnaires were input into a database to be modeled for analysis. Overall survey response rate is depicted in Table 5.2. Table 5.3 provides a breakdown of responses in terms of organizational participation.

Table 5.2: Breakdown of Responses

Total questionnaires distributed	Questionnaires returned	Total number of potential responses	Total valid responses received	Percentage of valid responses
2200	723	723	686	33.53%

Table 5.3: Breakdown of responses with respect to type of organization

Type of Organization	Approached	Responded	Response %
General Contractor	147	31	28.91%
Subcontractor	195	66	35.52%
Total	311	102	32.80%

The survey response rates depicted in Tables 5.1 and 5.2 (34.81% for individual participation and 32.80% for organizational participation) are very good for a construction industry questionnaire survey and should not be considered as biased (Akintoye and Macleod). In similar type of surveys, Panthi et al. (2007) received a response rate of 19.4%, Ahmed and Azhar (2004) received 30.4% and Wang et al. (2004) received a very low response rate of 7.75%. Baker (1998) reported that statistically reliable conclusions can be obtained from a sample size of 20 or more. Moreover, the conclusions drawn on the basis of the responses were further verified through interviews with experts, and hence can be considered as unbiased.

Figure 5.2 depicts information about distribution of respondent organizations in terms of their nature of work.

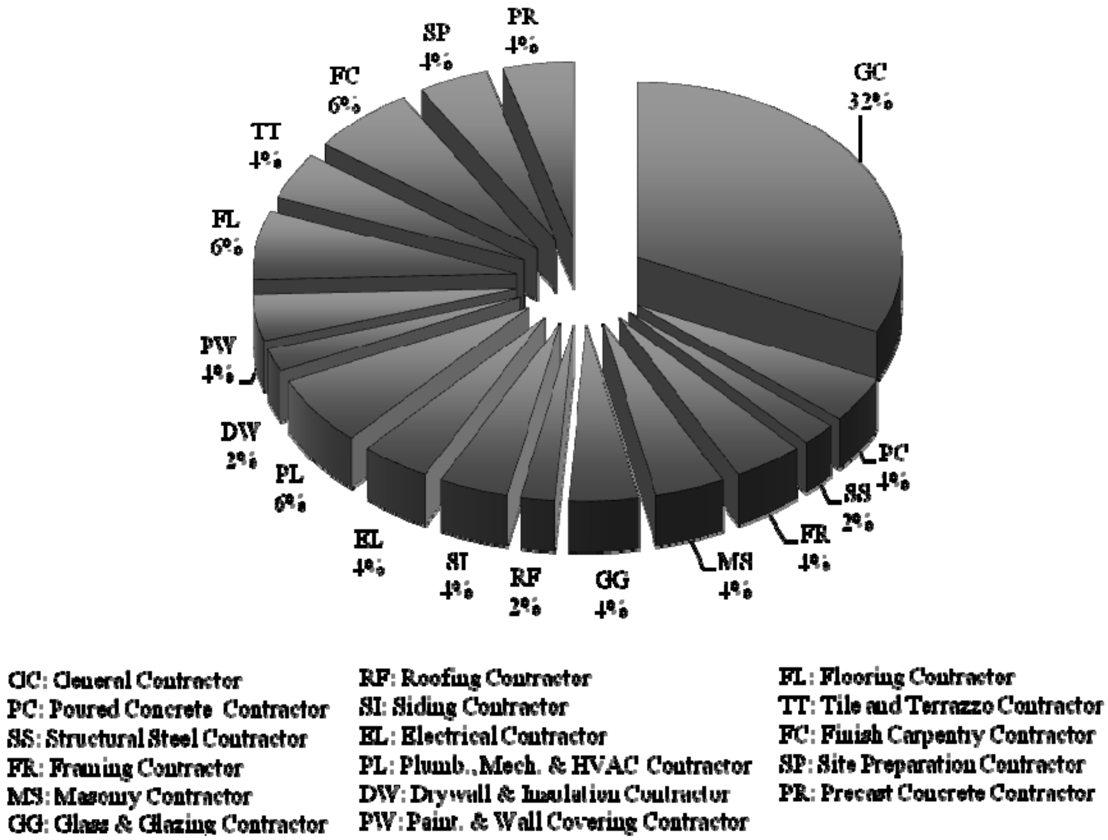

Figure 5.2: Type of Respondent Organizations

Figure 5.3 depicts information about the size of respondent organizations. The organization size is decided on the basis of number of employees as follows: 0-50→small; 51-250→medium; and >250→large. The results indicate that the majority of respondents are medium and large size companies. The annual turnover of these companies varies from $5 million to over $500 million.

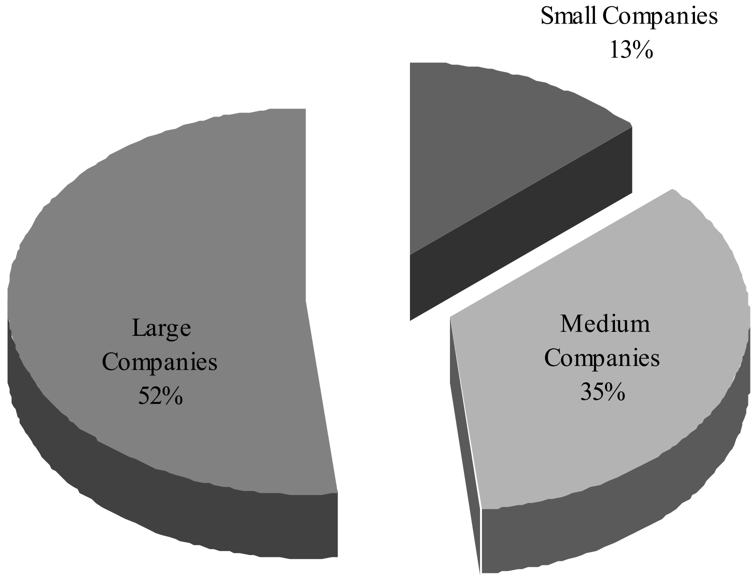

Figure 5.3: Size of Respondent Organizations

Field personal (supervisors, foremen, front line workers and helpers), middle management, and upper management all completed the questionnaire. Table 5.4 provides a share of respondents with respect to their work positions and organization type.

Table 5.4: Share of respondents with respect to their work positions and organization type

Type of Organization	Respondent Share (No. of respondents)			
	Upper Management	Middle Management	Field Personnel	Total (%)
General Contractor	44	67	126	237 (34.5%)
Subcontractor	93	117	239	449 (65.5%)
Total (%)	137 (20.0%)	184 (26.8%)	365 (53.2%)	

Demographic information for the survey respondents is presented in Tables 5.5(a) – 5.5(d).

Table 5.5(a): Participants' Construction Experience (Upper Management)

	Average Years	Most Experience	Least Experience
Years in Construction	27.13	36	14
Years as Executives	18.24	28	6

Table 5.5(b): Participants' Construction Experience (Middle Management)

	Average Years	Most Experience	Least Experience
Years in Construction	24.67	32	12
Years as Managers	15.49	24	5

Table 5.5(c): Participants' Construction Experience (Supervisors/ Foremen)

	Average Years	Most Experience	Least Experience
Years in Construction	20.42	37	11
Years as Supervisor/ Foremen	14.68	30	7

Table 5.5(d): Participants' Construction Experience (Workers)

	Average Years	Most Experience	Least Experience
Years in Construction	14.78	23	7
Years in Current Position	13.59	20	4

Table 5.6 presents the educational qualification of the participants. This wide range of formal education among the participants did not produce a wide range of differences in the data.

Table 5.6: Participants' Education

	Number of Participants	Post-Master's Degree	Master's Degree	Bachelor's Degree	Associate's Degree	Some College (No Degree)	High School Degree
Upper Management	137	9	33	69	14	8	4
Middle Management	184	12	48	79	22	14	9
Field Personnel	365	0	22	55	188	68	32
Total (%)	686	21 (3.06%)	103 (15.01%)	203 (29.59%)	224 (32.65%)	90 (13.12%)	45 (6.56%)

Table 5.6 shows that almost 80% of the participants had postsecondary degrees. A further diagnosis of the major concentrations for the postsecondary degrees held by these participants indicated that, including Civil Engineering and Architecture, 64% of the participants with a postsecondary degree had that degree in a construction related concentration (such as construction management, construction engineering and the like), 19% of the participants had that degree in business concentration (such as business administration and the like), while the remaining had diverse academic backgrounds ranging from majors in English, Psychology, Education, etc.

Overall, the data set (Table 5.6) accounts for a reasonable representation of the companies participating in this study, and produces statistically significant results as described later in this study.

It is worth mentioning that although safety perceptions are inherently individual, the safety dimensions questionnaire was developed to operate at both the individual and the group level. Salancik and Pfeffer (1978) argue that over time and through social information processing influences, individual perceptions can become shared and, as a result, can be aggregated and used to describe a group as a whole. In other words, this study expects that perceptions of safety and its determinants would be relatively homogeneous within the groups, constituting shared perceptions, and therefore could be aggregated to the group level of analysis. Therefore, the research model was tested using the total sample (combining all responses solicited from all organizations). This same approach has been used by previous researchers as well (such as Mohamed, 2002).

In accordance with established survey procedures and in recognition of the sensitive nature of the data collected, strict confidentiality was maintained during this survey research and no identities have been divulged.

5.8. Survey Validation

Research validation was done in three steps.

Firstly, it was confirmed that the survey was filled by personnel with appropriate profile and experience. Construction industry experience of respondents (Table 5.5) ranged from 4 to over 37 years. On the basis of their position and work experience, it was inferred that the respondents had adequate knowledge of safety related activities in their organizations as well as in the industry and their responses were a reasonable representation of required data.

Secondly, to avoid the problem of bias, it was decided not to use data provided by an organization with less than 5 responses survey. Based on this decision, data from nine (9) companies was discarded for survey (a total of 23 responses were received from these companies).

Moreover, 14 questionnaires were determined to be outliers and were also decided to be discarded. Hence a total of 37 questionnaires were discarded from the analysis.

Thirdly, the conclusions drawn on the basis of the responses were further verified through interviews with experts to ascertain that they were unbiased. Fourteen (14) face-to-face unstructured interviews were conducted in the vicinity of Miami, Florida from a selected cross-section of local construction industry experts to discuss the results and validate the findings. The targeted audience included top management, middle management and field personnel representing leading contractors and subcontractors working in the commercial building construction sector in the South Florida region.

The next section (section 5.9) details the employment of confirmatory factor analysis technique on the 83 measureable total safety characteristics to uncover the latent structure (underlying factors).

5.9 Confirmatory Factor Analysis

As identified in section 5.4, the three major safety dimensions along with their corresponding subcategories were broken down into 83 measurable indicators (survey items) defining total safety. The analysis technique used on the data set was structural equation modeling (SEM). This is explained in detail in chapter 6 Before the SEM analysis began, a rough estimate of the latent variables (constructs) was derived from a confirmatory factor analysis. Factor analysis is a tool used to uncover the latent structure (underlying dimensions) of a set of variables. It reduces attribute space from a larger number of variables to a smaller number of factors. Confirmatory factor analysis seeks to determine if the number of factors and the loadings of measured (indicator) variables on them conform to what is expected on the basis of pre-established theory. Indicator variables are selected on the basis of prior theory and factor analysis is used to see if they load as predicted on the expected number of factors. Underlying dimensions (constructs) imply ways to combine variables, in this case, aspects of safety dimensions, thereby simplifying subsequent analysis (Hamilton 1992; SPSS 2001). A principal factor analysis (PFA) using the varimax rotation method with Kaiser normalization was utilized. The rotation converged in 13 iterations. PFA works as follows.

PFA is used when the research purpose is theory confirmation and causal modeling. It analyzes a correlation matrix in which the diagonal contains the communalities. PFA accounts for the covariation among variables. Factors reflect the common variance of the variables, excluding unique (variable-specific) variance. That is, manifest variables may be conceptualized as reflecting a combination of common variance explained by the factors, plus unique variance not explained by the factors. Factors seek to reproduce the correlations of the variables. That is, PFA accounts for the covariation among the variables. PFA seeks the least number of factors which can account for the covariance shared by a set of variables. For the first factor, PFA creates a linear equation which extracts the maximum covariance from the variables; for the second component PFA removes the covariance explained by the first component and creates a second linear equation which extracts the maximum remaining covariance; etc., continuing until the factors can explain all the covariance in a set of variables.

In confirmatory factor analysis, loadings should be 0.7 or higher to confirm that independent variables identified a priori are represented by a particular factor, on the rationale that the 0.7 level corresponds to about half of the variance in the indicator being explained by the factor (Fornell and Larcker 1981).

Based on the factor analysis results, the 83 measureable characteristics defined in the 22 subcategories of the 3 principal categories of factor sets were reduced into 6 constructs (latent variables/ factors/ underlying dimensions), viz., (1) Safety commitment (C); (2) Personal safety character and competence (I); (3) Supportive work environment (E); (4) Work pressure (P); (5) Safety program (R); and (6) Safety strategic concern (S).

Obtained values for the measured items in these 6 constructs exceeded the threshold of 0.7, with majority of loadings in the range of 0.75–0.85. Note that the 83 indicators (survey items) constituting the six constructs span across multiple branches of the multiattribute hierarchy as shown in Table 5.7. The number in each cell of Table 5.7 indicates the number of responses (indicators/ items in questionnaire) influenced by a particular construct. This is established by sound theoretical basis (Molenaar et al., 2009; Lo 1996; Groover and Krause 1993; Preston and Topf, 1994; Hodson and Graham, 1998; Mohamed, 2002) and confirmed by principal factor analysis.

Table 5.7: Safety Dimension Subcategories Constituting the Model Constructs

Safety Dimension Subcategories \ Model Constructs	C	I	E	P	R	S	Total (Items in each subcategory)
Personal Intention & Commitment	1	1					2
Personal Value System	1	1					2
Personal Attitude & Perception	1	1					2
Personal Interpretation & Emotion	1	1		1			3
Personal Proficiency		7					7
Management Commitment & Involvement	3		2			2	7
Workers' Commitment & Involvement	2		2			1	5
Supervisory Commitment and Involvement	2		3	1		1	7
Subcontractor Commitment & Involvement			2			1	3
Communication			2			2	4
Work Environment			5				5
Safety Accountability			1			1	2
Production Pressure				7			7
Cultural Norms	1		1	1			3
Shared Values	1		1			1	3
Collective Beliefs/ Shared Understanding			1			1	1
Safety Rules and Procedures					5		5
Site Layout Planning			2		1	1	4
Safety Training and Education		1			2	1	4
Accident Investigation and Reporting		1			2	1	4
Safety Incentive Mechanisms						1	1
Safety Disincentive Mechanisms					1		1
Total (Items in each construct)	13	13	22	10	11	14	83

*C=safety commitment; I=personal safety character and competence; E=supportive work environment; P=work pressure; R=safety program; and S = safety strategic concern

5.10 Conclusion

This research has adopted an integral approach to safety as a means of measuring and improving total safety in a construction organization. This approach decomposed total safety into four principal dimensions, viz., person, culture, behavior and process. Extensive literature review and expert input provided the basis to further decompose the four safety dimensions into 83 measurable attributes using a multiattribute analysis technique, which formed the basis of a questionnaire to measure total safety. Safe work behavior was selected as a measure of a company's safety performance for the study. Based on the survey responses, statistical relationships between total safety dimensions and safety performance (measured by safe work behavior) were revealed through a series of six latent variables (factors) that describe the total safety environment of a construction organization. This was achieved using confirmatory factor analysis (CFA) which reduced the attribute space from a larger number of safety sub-categories to a smaller number of underlying factors. These factors (6) have been concluded to be most suitable and appropriate for measurement and continuous improvement of total safety in a construction organization and hence play a pivotal role in achieving and sustaining the goal of zero accidents. These factors (and their corresponding indicators) form the basis of a strategic safety improvement model for the construction industry, the development and discussion of which is discussed in the next chapter.

CHAPTER 6

MODEL DEVELOPMENT

6.1 Introduction

The previous chapter established the factors (latent variables/ constructs) determining the total safety environment of a construction contracting organization, which are most suitable and appropriate for measurement and improvement and hence play a pivotal role in achieving the goal of zero accidents. This chapter discusses the development of a strategic safety improvement model based on the identified factors and their associated indicators. This constitutes achieving objectives 3 of the study, i.e. to develop a strategic model to measure the effect of the key determinants of total safety (the critical factors) on a construction organization's safety performance.

From data collected in phase II of the research (chapter 5), a research base model was developed. Following this, a structural equation model (SEM) was estimated to identify latent constructs that describe total safety and to quantify relationships among them and between these total safety determinants and safety performance of a construction organization. A detailed description of the modeling process is presented as a basis for the presentation of the SEM findings. Latent variables that describe total safety are discussed and so is the correlation between total safety dimensions and the safety performance of a company.

Finally, the strategic framework is presented along with a discussion of the key components of the framework and their utility towards strategically improving safety in the construction industry for achieving and sustaining the goal of zero accidents.

6.2 Model Constructs and Hypotheses

The research base model follows the broad hypothesis that safe work behaviors (and, thus, their reciprocal, unsafe behaviors) are consequences of the existing safety dimensions in a construction organization, which is determined by the three inter-dependent sets of factors identified earlier — i.e., person, culture and process. Therefore, the model has two distinct components – (1) determinants of safety (person, culture, and process sets of factors); and (2) measurement of safety (safe work behaviors). Although a number of recent studies have investigated the impact of one or more elements of the above factors on construction safety levels (Rowlinson 1997; Lingard and Rowlinson 1998; Sawacha et al. 1999; Mohamed, 2002; Molenaaar, 2009), their integral relationship with safe work behaviors, specifically, has not been measured before. Also, the interrelationships among these factors defining total safety, in an integrative or sequential fashion, have not been analyzed before. Description of these constructs and the hypotheses associated with each path of the model are discussed in the following sub-sections.

6.2.1. Safety Commitment (C)

The construct *safety commitment* influenced the responses to 9 questions on the survey questionnaire. These variables span across 8 branches of the multiattribute hierarchy, including: personal intention & commitment (1), personal value system (1), personal attitude & perception (1), management commitment & involvement (2), workers' commitment & involvement (1), supervisory commitment & involvement (1), cultural norms (1), and shared values (1) All 9 variables share the common thread of the company's commitment to safety. Thus, *hypothesis 1* – The greater the level of company's commitment toward safety, the more positive the safe work behaviors.

6.2.2. Personal Safety Character and Competence (I)

The construct *personal safety character and competence* influenced the responses to 7 questions on the survey questionnaire. These variables span across 5 branches of the multiattribute hierarchy, including: personal intention & commitment (1), personal value system (1), personal interpretation & emotion (1), personal proficiency (3), and safety training & education (1). All 7 variables share the common thread of a person's safety character and competence. Thus, *hypothesis 2* – The better one's safety character and competence, the more positive the safe work behaviors.

6.2.3. Supportive Work Environment (E)

The construct *supportive work environment* influenced the responses to 10 questions on the survey questionnaire. These variables span across 8 branches of the multiattribute hierarchy, including: management commitment & involvement (1), workers' commitment & involvement (1), supervisory commitment & involvement (2), subcontractor commitment and involvement (1), communication (2), safety accountability (1), collective beliefs/ shared understanding (1), and site layout planning (1). All 10 variables share the common thread of a supportive work environment. Thus, *hypothesis 3* – The higher the level of support provided by the constituent members of the work environment, the more positive the safe work behaviors.

6.2.4. Work Pressure (P)

The construct *work pressure* influenced the responses to 6 questions on the survey questionnaire. These variables span across 4 branches of the multiattribute hierarchy, including: personal interpretation & emotion (1), supervisory commitment & involvement (1), production pressure (3), and cultural norms (1). All 6 variables share the common thread of work pressure. Thus, *hypothesis 4* – The higher the perception of valuing expediency over safety, the less positive the safe work behaviors.

6.2.5. Safety Program (R)

The construct *safety program* influenced the responses to 8 questions on the survey questionnaire. These variables span across 5 branches of the multiattribute hierarchy, including: safety rules and procedures (3), site layout planning (1), safety training and education (2), accident investigation and reporting (1), and safety disincentive mechanisms (1). All 8 variables share the common thread of safety program. Thus, *hypothesis 5* – The better the implementation of safety program, the more positive the safe work behaviors.

6.2.6. Safety Strategic Concern

The construct *safety strategic concern* influenced the responses to 10 questions on the survey questionnaire. These variables span across 9 branches of the multiattribute hierarchy, including: management commitment & involvement (2), workers' commitment & involvement (1), supervisory commitment & involvement (1), subcontractor commitment & involvement (1), communication (1), safety accountability (1), safety training and education (1), accident investigation and reporting (1), and safety incentive mechanisms. All 10 variables share the common thread of strategic concern to safety. Thus, *hypothesis 6* – The higher the safety strategic concern, the more positive the safe work behaviors.

6.2.7. Safe Work Behaviors

The last construct relates to safe work behavior. The model hypothesizes that total safety dimensions affect safe work behavior. Grubb and Swanson (1999) report that construction workers acknowledge the difference between unsafe behaviors that might result in injury to the individual (who is engaged in the action) and those that might lead to others being injured. They conclude that workers are more willing to confront someone whose behavior is posing a threat to coworkers' safety. As a result, two items (Brown et al., 2000; Mohamed, 2002) were selected to assess the dependent construct of safe work behavior. Respondents were asked to indicate, on average, the percentage of time workers and their coworkers follow all of the safety procedures for the jobs that they perform. Thus, *hypothesis 7* – High level of total safety is positively associated with higher level of safe work behavior.

6.3 Data Modeling

The research hypotheses were tested using structural equation modeling (SEM). The SEM is a statistical analysis tool used largely by sociologists and psychologists. It is, however, underutilized in construction engineering and management research despite its distinct advantages (Molenaar et al. 2009). SEM is a multivariate methodology that allows the simultaneous examination of the relationships among independent and dependent constructs within a theoretical model (Kilne 1998). The following sub-section provides a brief background of the SEM analysis technique.

6.3.1. SEM Analysis Technique

Many of the problems, or research issues, in construction engineering and management involve the measurement of concepts that are not easily quantified. For instance, personal appreciation of risk, top management commitment, teamwork, personal competence, and supervisory support are concepts that previous research has proven to be critical to developing a total safety culture in an organization but difficult for researchers to measure. There has been a trend toward the use of multivariate regression techniques to measure such concepts (Russell and Jaselskis 1992; Sanders and Thomas 1993; Diekmann and Girard 1995; and Molenaar and Songer 1998). Although standardized multivariate regression analysis techniques have proven successful, there is a fundamental flaw with their use. A basic premise of standard regression techniques is that independent variables used to build the regression models are measured without error. This is often not the case. For instance, top management commitment is not directly measurable and is typically measured through ''surrogate'' variables that make up management commitment (i.e., management's expression of concern to safety issues, its decisive actions when a safety concern is raised, its quick response to correct safety problems, etc.). Because many of these surrogate variables do not perfectly measure the prime variable of interest, technical problems in model estimation arise, resulting in diminished ability to conduct statistical inference with a standard regression model. Structural equation modeling (SEM) analysis can be thought of as an extension of standardized regression modeling that deals explicitly with poorly measured independent variables. Structural equation models are ideally suited for many of the research issues dealt with in construction engineering and management.

This research specifically utilizes the application of SEM to construction safety. The causes of worker safe (and their reciprocal unsafe) behaviors stem from multiple factors, which are not all directly measurable (termed latent variables). The SEM analysis offers a method for modeling latent variables by explicitly including errors of measurement brought about by surrogate variables, thus providing insight into the factors that can be used to understand the susceptibility of a worker to unsafe behaviors and hence accidents.

The use of SEM allows for a richer analysis of the causes of worker unsafe behaviors. The SEM analysis of the data set helps identify new relationships among project variables that lend new insight into the measurement of construction safety.

Structural equation modeling (SEM) encompasses such diverse statistical techniques as path analysis, confirmatory factor analysis, causal modeling with latent variables, and even analysis of variance and multiple linear regression. The following sub-sections feature an introduction to the logic of SEM, the assumptions and required input for SEM analysis, and the procedure to perform SEM analyses using the AMOS (Analysis of Moment Structures) software, which has been utilized for this study.

6.3.1.1. SEM Analysis Overview

The basic approach to performing a SEM analysis is as given in Figure 6.1.

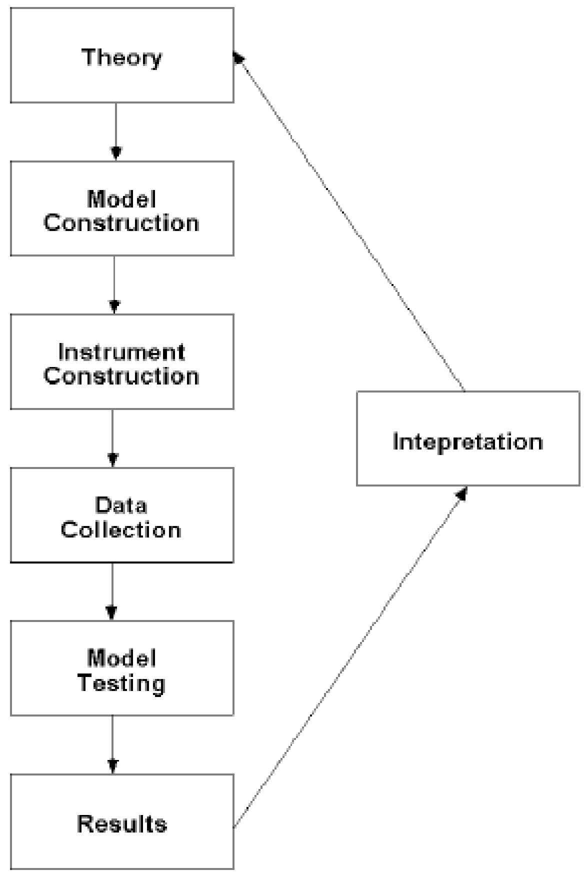

Figure 6.1: Basic Approach to Performing a SEM Analysis

The researcher first specifies a model based on theory, then determines how to measure constructs, collects data, and then inputs the data into the SEM software package. The package fits the data to the specified model and produces the results, which include overall model fit statistics and parameter estimates. Note that the same approach has been used for the research in hand.

The SEM process can be schematically shown as Figure 6.2.

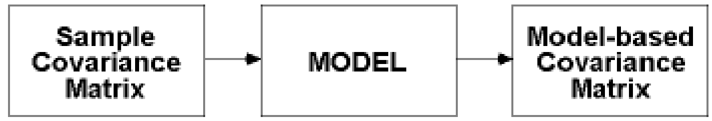

Figure 6.2: SEM Process Schematic

The input to the analysis is usually a covariance matrix of measured variables such as survey item scores in case of this research. In practice, the data analyst usually supplies SEM program with raw data (survey item scores), and the program converts these data into covariances and means for its own use.

The model consists of a set of relationships among the measured variables. These relationships are then expressed as restrictions on the total set of possible relationships.

The results feature overall indexes of model fit as well as parameter estimates, standard errors, and test statistics for each free parameter in the model.

6.3.1.2 SEM Nomenclature

SEM has a language all its own.

Indicators are observed variables, sometimes called manifest variables or reference variables. These variables are directly measured by researchers. In case of this research, indicators are items in the survey instrument.

Four or more indicators are recommended and three are acceptable and common practice. The prime consideration in selecting indicators is whether they are theoretically sound and reliably measured. By convention, indicators should have pattern coefficients (factor loadings) of .7 or higher on their latent factors. In case of research in hand, there are a minimum of 6 indicators per factor, and all factor loadings are .7 or higher.

Latent variables are the unobserved variables or constructs or factors which are not directly measured but are inferred by the relationships or correlations among their respective indicators in the analysis. This statistical estimation is accomplished in much the same way that an exploratory factor analysis infers the presence of latent factors from shared variance among observed variables. Latent variables include independent, mediating, as well as dependent variables. The representation of latent variables based on their relation to observed indicators is one of the defining characteristics of SEM. In case of research in hand, the latent variables defining total safety are: safety commitment, personal safety character and competence, supportive work environment, work pressure, safety program, safety strategic concern, and safe work behavior.

It is important to note here that indicators cannot be combined arbitrarily to form latent variables. For instance, combining gender, race, or other demographic variables to form a latent variable called "background factors" would be improper because it would not represent any single underlying continuum of meaning. The confirmatory factor analysis step in SEM is a test of the meaningfulness of latent variables and their indicators. In case of research in hand, confirmatory factor analysis was done (as given in section 5.9) to combine indicators to form latent factors.

Exogenous or upstream variables are independent variables with no prior causal variable (though they may be correlated with other exogenous variables, depicted by a double-headed arrow). In fact it is customary to assume that exogenous variables are correlated (connected by a double-headed covariance arrow) unless there is theoretical reason not to. If two exogenous variables are connected by a covariance arrow, there cannot also be a straight (regression path) arrow between them.

Endogenous or downstream variables are dependent variables and can be either ultimate dependent variables (variables which are effects of other exogenous or mediating variables, and are not causes of other endogenous variables), or mediating variables (variables which are effects of other exogenous or mediating variables, and are also causes of other mediating or ultimate dependent variables). Endogenous variables are on the receiving end of single-headed straight arrows indicating a regression path and implying a causal relationship. The path to the endogenous variable may come from an exogenous variable or another endogenous variable.

The key distinction between exogenous and endogenous variables comes from the fact that whether the variable regresses on another variable or not. As in regression the dependent variable (DV) regresses on the independent variable (IV), meaning that the DV is being predicted by the IV. In SEM terminology, other variables regress on exogenous variables. Exogenous variables can be recognized in a graphical version of the model, as the variables sending out arrowheads, denoting which variable it is predicting. A variable that regresses on a variable (compare with a DV in regression analysis) is always an endogenous variable, even if this same variable is also used as a variable to be regressed on (now it can be more appropriately called a mediating endogenous variable). Endogenous variables are recognized as the receivers of a single-headed arrow in the model.

In case of research in hand, the exogenous variables defining total safety are: safety commitment, personal safety character and competence, supportive work environment, work pressure, safety program, and safety strategic concern, and the endogenous variable defining safety performance (in fact an ultimate dependent variable) is safe work behavior.

It is important to note here that SEM is more general than regression. In particular a variable can act as both independent and dependent variable.

6.3.1.3 SEM Modeling Approaches

SEM is usually viewed as a confirmatory rather than exploratory procedure, using one of three approaches:

1. Strictly confirmatory approach: A model is tested using SEM goodness-of-fit tests to determine if the pattern of variances and covariances in the data is consistent with a structural (path) model specified by the researcher. However as other unexamined models may fit the data as well or better, an accepted model is only a not-disconfirmed model.
2. Alternative models approach: One may test two or more causal models to determine which has the best fit. There are many goodness-of-fit measures, reflecting different considerations, and usually three or four are reported by the researcher. Although desirable in principle, this AM approach runs into the real-world problem that in most specific research topic areas, the researcher does not find in the literature two well-developed alternative models to test.
3. Model development approach: In practice, much SEM research combines confirmatory and exploratory purposes: a model is tested using SEM procedures, found to be deficient, and an alternative model is then tested based on changes suggested by SEM modification indexes. This is the most common approach found in the literature.

Regardless of approach, SEM cannot itself draw causal arrows in models or resolve causal ambiguities. Theoretical insight and judgment by the researcher is still of utmost importance.

In case of research in hand, model development approach to SEM has been utilized because it provides a way to confirmatory and exploratory purposes.

6.3.1.4 SEM Modeling Process

The structural equation modeling process centers around two steps: validating the measurement model and fitting the structural model. The former is accomplished primarily through confirmatory factor analysis, while the latter is accomplished primarily through path analysis with latent variables.

6.3.1.5. The Measurement Model

The measurement model (Figure 6.3) is that part (possibly all) of a SEM model which deals with the latent variables and their indicators. One starts by specifying a model on the basis of theory. Each variable in the model is conceptualized as a latent one, measured by multiple indicators. Several indicators are developed for each variable, with a view to winding up with at least two and preferably three per latent variable after confirmatory factor analysis. Based on a large (n>100) representative sample, factor analysis (common factor analysis or principal axis factoring, not principle components analysis) is used to establish that indicators seem to measure the corresponding latent variables, represented by the factors. A pure measurement model is a confirmatory factor analysis (CFA) model in which there is unmeasured covariance between each possible pair of latent variables, there are straight arrows from the latent variables to their respective indicators, there are straight arrows from the error terms to their respective variables, but there are no direct effects (straight arrows) connecting the latent variables. Note that "unmeasured covariance" means one almost always draws two-headed covariance arrows connecting all pairs of exogenous variables (both latent and simple, if any), unless there is strong theoretical reason not to do so. The measurement model is evaluated like any other SEM model, using goodness of fit measures. There is no point in proceeding to the structural model until one is satisfied that the measurement model is valid.

6.3.1.6. The Structural Model

The structural model (Figure 6.4) may be contrasted with the measurement model. It is the set of exogenous and endogenous variables in the model, together with the direct effects (straight arrows) connecting them, and any correlations among the exogenous variable or indicators. Two or more alternative models are compared in terms of "model fit," which measures the extent to which the covariances predicted by the model correspond to the observed covariances in the data. "Modification indexes" and other coefficients may be used by the researcher to alter one or more models to improve fit.

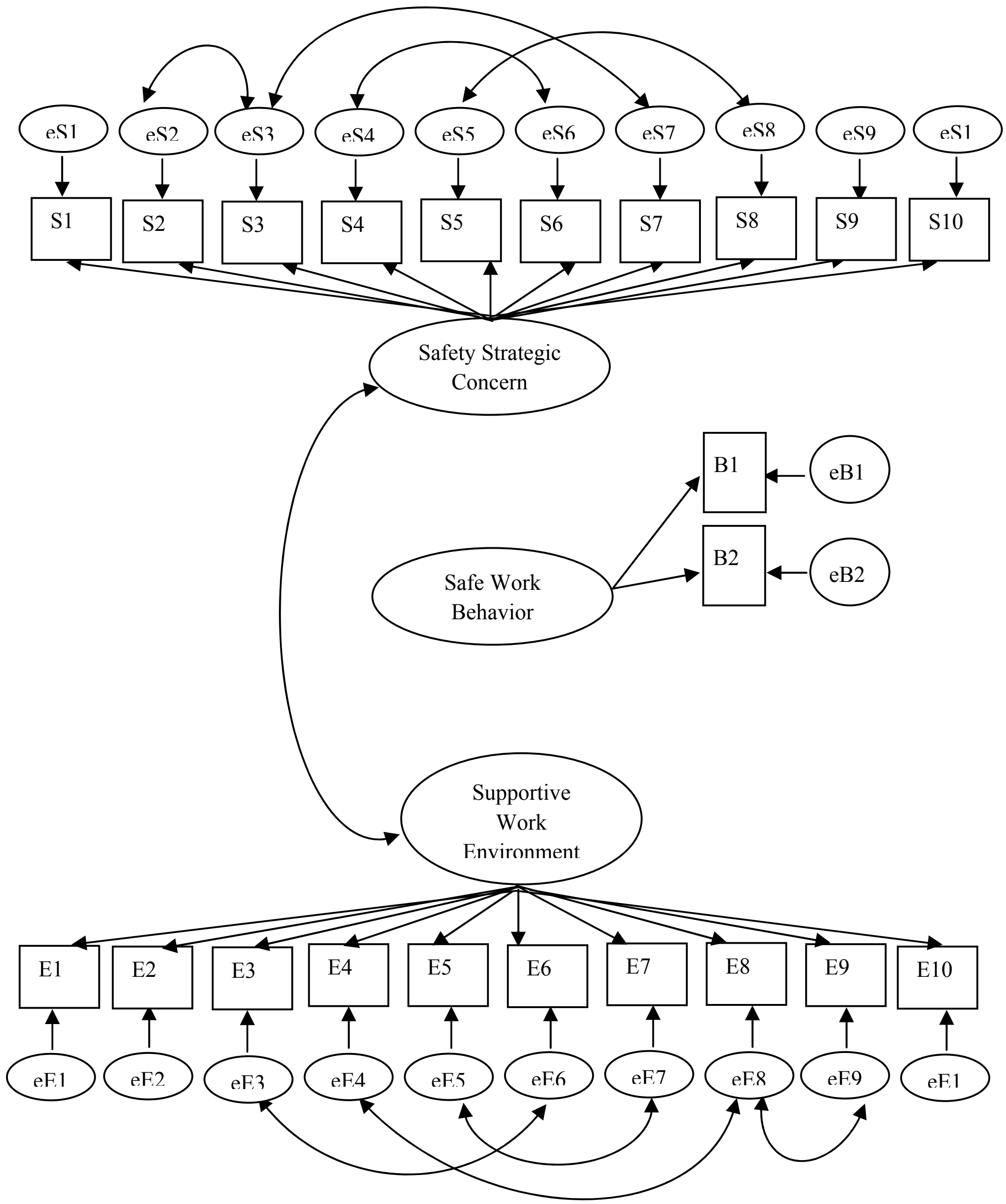

Figure 6.3: SEM Measurement Model

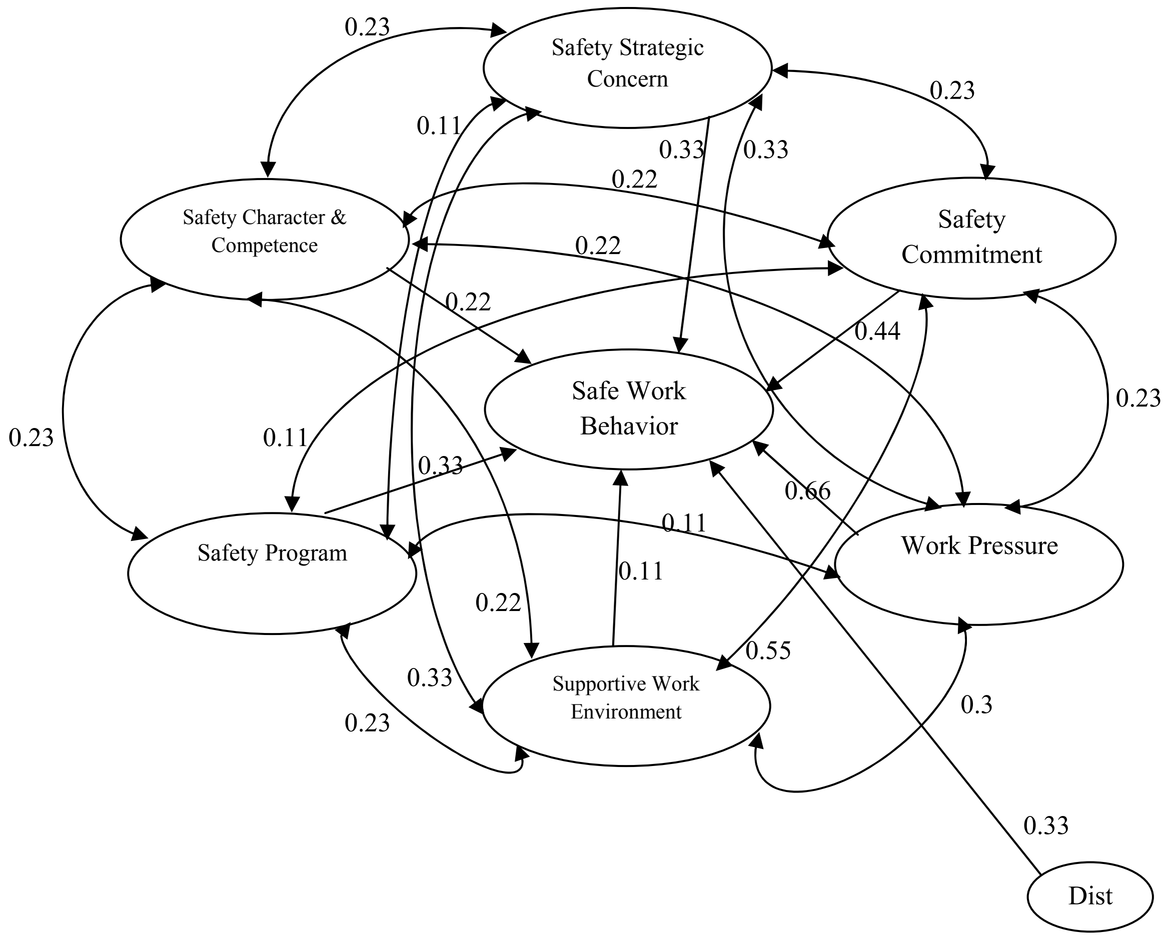

Figure 6.4: SEM Structural Model

6.3.1.7. Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is used to confirm that the indicators sort themselves into factors corresponding to how the researcher has linked the indicators to the latent variables in the measurement model. Confirmatory factor analysis plays an important role in structural equation modeling. CFA models in SEM are used to assess the role of measurement error in the model, to validate a multifactorial model, and to determine group effects on the factors. CFA has been utilized in the research in hand and the results have been given in section 5.9.

6.3.1.8. Reliability

Cronbach's alpha is a commonly used measure testing the extent to which multiple indicators for a latent variable belong together. It varies from 0 to 1.0. A common rule of thumb is that the indicators should have a Cronbach's alpha of .7 to judge the set reliable. Reliability analysis has been performed for the research in hand and the results have been given in section 6.3.2.1.

6.3.1.9. Measurement Error Terms

A measurement error term refers to the measurement error factor associated with a given indicator. Whereas regression models implicitly assume zero measurement error (that is, to the extent such error exists, regression coefficients are attenuated), error terms are explicitly modeled in SEM and as a result path coefficients modeled in SEM are unbiased by error terms, whereas regression coefficients are not. Though unbiased statistically, SEM path coefficients will be less reliable when measurement error is high. Figure 6.3 shows the measurement error terms in SEM model developed for this research. Note that Figure 6.3 is only a partial measurement model developed in this research.

6.3.1.10. Correlated Error Terms

Correlated error terms refer to situations in which knowing the residual of one indicator helps in knowing the residual associated with another indicator. For instance, in survey research many people tend to give the response which is socially acceptable. Knowing that a respondent gave the socially acceptable response to one item increases the probability that a socially acceptable response will be given to another item. Such an example exhibits correlated error terms. Uncorrelated error terms are an assumption of regression, whereas the correlation of error terms may and should be explicitly modeled in SEM. That is, in regression the researcher models variables, whereas in SEM the researcher must model error as well as the variables (see Figure 6.3).

6.3.1.11. Structural Error Terms

The measurement error terms discussed above are not to be confused with structural error terms, also called residual error terms or disturbance terms, which reflect the unexplained variance in the latent endogenous variable(s) due to all unmeasured causes. In Figure 6.4, the "Dist" term is a disturbance term/structural error term.

6.3.1.12. Metric

In SEM, each unobserved latent variable must be assigned explicitly a metric, which is a measurement range. This is normally done by constraining one of the paths from the latent variable to one of its indicator (reference) variables, as by assigning the value of 1.0 to this path. Given this constraint, the remaining paths can then be estimated. The indicator selected to be constrained to 1.0 is the reference item. Typically one selects as the reference item the one which in factor analysis loads most heavily on the dimension represented by the latent variable, thereby allowing it to anchor the meaning of that dimension. Note that if multiple samples are being analyzed, the researcher should use the same indicator variable in each sample to assign the metric.

Alternatively, one may set the factor variances to 1, thereby effectively obtaining a standardized solution. This approach of obtaining a standardized SEM solution has been employed in the research in hand.

6.3.1.13. SEM Software Packages

ISREL, AMOS, and EQS are three popular statistical packages for doing SEM. AMOS (Analysis of MOment Structures) is a more recent package which, because of its user-friendly graphical interface, has become popular as an easier way of specifying structural models and is the software used in the research in hand.

6.3.1.14. Sample SEM Model

As discussed earlier, two main components of models are distinguished in SEM: the structural model showing potential causal dependencies between endogenous and exogenous variables, and the measurement model showing the relations between latent variables and their indicators. Exploratory and Confirmatory factor analysis models, for example, contain only the measurement part, while path diagrams can be viewed as an SEM that only has the structural part.

Figure 6.5 shows a partial SEM model (part of the full model) taken from the current research in hand.

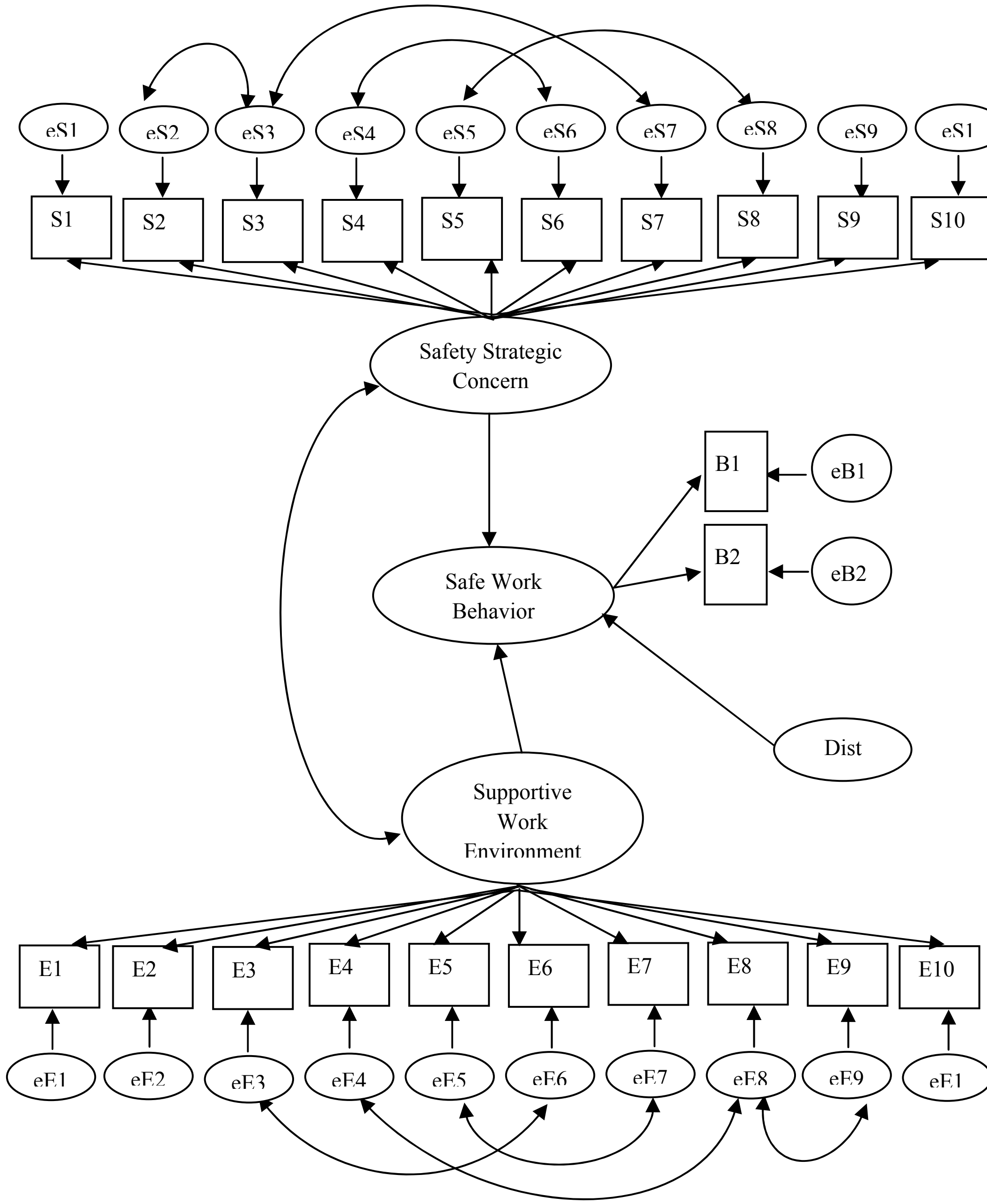

Figure 6.5: Example SEM Model

In Figure 6.5, note the following model components:

a. The exogenous latent variables Safety Strategic Concern and Supportive Work Environment, measured by the indicator variables S1-S10 and E1-E10 respectively.
b. The endogenous latent variable Safe Work Behavior is measured by indicator variables B1-B2 and regressed by the exogenous variables Safety Strategic Concern and Supportive Work Environment.
c. Indicator and other measured variables are depicted as rectangles by convention.
d. Latent variables are depicted as ovals by convention.
e. Causal effects are represented by single-headed arrows in the path diagram.
f. Safety Strategic Concern causes the scores observed on the indicator variables S1-S10, and Supportive Work Environment causes the scores observed on the indicator variables E1-E10, and Safe Work Behavior causes the scores observed on the indicator variables B1-B2. Safety Strategic Concern can be conceptualized as the variance its 10 indicators S1-S10 share i.e., what the 10 indicators have in common.
g. The single-headed arrows from Safety Strategic Concern to Safe Work Behavior and from Supportive Work Environment to Safe Work Behavior hypothesize that Safe Work Behavior is caused by Safety Strategic Concern and Supportive Work Environment.
h. eS1 to eS10, eE1 to eE10 and eB1 to eB2 are the error or residual terms associated with each indicator variable that also cause response variation in the

indicator variables. Since residuals are always unobserved, they are represented by ovals.

i. The two-headed (bidirectional) arrow between Safety Strategic Concern and Supportive Work Environment indicates that Supportive Work Environment is thought to have a correlation or covariance with Safety Strategic Concern. Note that bidirectional arrows represent relationships without an explicitly defined causal direction. For instance, Safety Strategic Concern Perform and Supportive Work Environment are related or associated, but no claim is made about one causing the other.

j. As is usual, there is a disturbance or error term, Dist, associated with the endogenous latent variable, Safe Work Behavior.

The model in Figure 6.5 depicts that scores or responses on survey items one through twenty (S1-S10 & E1-E10) are caused by two correlated factors, along with variance that is unique to each item. Some of that unique variance might be due to measurement error.

6.3.1.15. SEM Advantages

The following are the specific advantages of SEM that led the researcher to select this method as the preferred method of analysis.

- Assumptions underlying the statistical analyses are clear and testable, giving the investigator full control and potentially furthering understanding of the analyses.
- Use of confirmatory factor analysis to reduce measurement error by having multiple indicators per latent variable.
- Graphical interface software boosts creativity and facilitates rapid model debugging.

- SEM programs provide overall tests of model fit and individual parameter estimate tests simultaneously.
- SEM models can be used to purge errors, making estimated relationships among latent variables less contaminated by measurement error.

Although multiple regression analysis has most commonly been used to find indicators of safety performance (Jaselskis et al. 1996), SEM was selected as the analytical tool to measure the effect of safety dimensions on safety performance. In this case, regression analysis will have two significant problems. First, safety dimensions constitute many unobserved, or latent variables and these variables are likely to be interrelated. A fundamental premise of multiple regression analysis is that all variables are assumed to be independent. In the case of modeling safety dimensions, there will likely be problems of multi-collinearity caused by the interdependency between independent variables. The second problem is that standard multiple regression techniques ignore measurement error. There is inherent measurement error in survey data of this type, stemming from inaccurate ratings on a Likert scale. When measurement errors in independent variables are incorporated into a regression equation (via a poorly measured variable) in standard fashion, the variances of the measurement errors in the regressors are transmitted to the model error, thereby inflating the model error variance (Myers 1990). In other words, measurement errors will result in greater estimated model variances and measurement errors in independent variables can cause irreconcilable technical problems.

The standardized coefficients in a SEM can possess more reliable estimates of how an exogenous variable affects an endogenous variable than what is produced with multiple regression analysis. There are two basic premises in SEM to overcome these problems of multiple regression analysis. First, SEM typically incorporates the covariance matrix of the independent and dependent variables. It uses a maximum likelihood estimation procedure to derive the "most likely" coefficient values, given the actual covariance matrix. The second premise is that SEM establishes the relationships between unobservable—termed latent variables and attempts to account for random measurement error that cannot be employed by multiple regression analysis.

6.3.1.16. SEM Model Specification

Model Specification is the process by which the researcher asserts which effects are null, which are fixed to a constant (usually 1.0), and which vary. Variable effects correspond to arrows in the model, while null effects correspond to an absence of an arrow. Fixed effects usually reflect either effects whose parameter has been established in the literature (rare) or more commonly, effects set to 1.0 to establish the metric for a latent variable.

6.3.1.17. Model Parsimony

A model in which no effect is constrained to 0 (hence there is an arrow from every variable to every other variable) is one which will always fit the data, even when the model makes no sense. The closer one is to this most-complex model, the better will be one's fit. That is, adding paths will tend to increase fit. This is why a number of fit measures (discussed below) penalize for lack of parsimony. Note lack of parsimony may be a particular problem for models with few variables. Ways to decrease model complexity are erasing direct effects (straight arrows) from one latent variable to another; erasing direct effects from multiple latent variables to the same indicator variable; and erasing unanalyzed correlations (curved double-headed arrows) between measurement error terms and between the disturbance terms of the endogenous variables. In each case, arrows should be erased from the model only if there is no theoretical reason to suspect that the effect or correlation exists.

The most parsimonious model is the one with the fewest arrows, which means the fewest coefficients. However, much more weight should be given to parsimony with regard to structural arrows connecting the latent variables than to measurement arrows from the latent variables to their respective indicators. Also, if there are fewer variables in the model and yet the dependent is equally well explained, that is parsimony also; it will almost always mean fewer arrows due to fewer variables. (In a regression context, parsimony refers to having the fewest terms (and hence fewest coefficients) in the model, for a given level of explanation of the dependent variable.)

6.3.1.18. Model Comparisons

Model-building and model-trimming involve comparing a model which is a subset of another. Chi-square difference can be used directly for hierarchical models. This is because model fit by chi-square is partly a function of model complexity, with more complex models fitting better. For non-hierarchical model comparisons, the researcher needs to use a fit index which penalizes for complexity (rewards parsimony), such as Akaiki information criterion (AIC).

6.3.1.18.1. Modification Indices

Modification indices (MI) are related to the Lagrange Multiplier (LM) test or index because MI is a univariate form of LM. MI is often used to alter models to achieve better fit, but this needs to be done carefully and with theoretical justification. In MI, improvement in fit is measured by a reduction in chi-square. In AMOS, the modification indexes have to do with adding arrows: high MI's flag missing arrows which might be added to a model.

6.3.1.18.2. Par Change

Par change is an effect size measure. AMOS output will list the parameter (which arrow to add or to subtract), the chi-square value (the estimated chi-square value for this path, labeled "M.I."), the probability of this chi-square (significant ones are candidates for change), and the "parameter change," which is the estimated change in the new path coefficient when the model is altered (labeled "Par Change"). 'Par change" is the estimated coefficient change when adding arrows. The MI and the parameter change should be looked at jointly. The researcher may decide not to add an arrow indicated by MI if the parameter change is trivial. Likewise, the researcher may wish to add an arrow where the parameter change is large in absolute size even if the corresponding MI is not the largest one.

6.3.1.18.3. Covariances

In the case of modification indexes for covariances, the MI has to do with the decrease in chi-square if the two error term variables are allowed to correlate. For instance, in AMOS, if the MI for a covariance is 24 and the "Par Change" is .8, this means that if the model is respecified to allow the two error terms to covary their covariance would be expected to change by .8, leading to a reduction of model chi-square by 24 (lower is better fit). If there is correlated error, as shown by high MI's on error covariances, causes may include redundant content of the two items, methods bias (for example, common social desirability of both items), or omission of an exogenous factor (the two indicators share a common cause not in the model). If MI and Par Change indicate that model fit will increase if a covariance arrow is added between indicator error terms, this should only be done if strong theoretical evidence suggests as such.

6.3.1.18.4. Structural (Regression) Weights

In the case of MI for estimated regression weights, the MI has to do with the change in chi-square if the path between the two variables is restored (adding an arrow).

6.3.1.18.5. Rules of Thumb for MIs

One arbitrary rule of thumb is to consider adding paths associated with parameters whose modification index exceeds 100. However, another common strategy is simply to add the parameter with the largest MI (even if considerably less than 100), then see the effect as measured by the chi-square fit index. The latter approach is adopted by the research in hand for model fit improvement.

6.3.1.18.6. Chi-Square Difference Test

Chi-square difference test, also called the Likelihood Ratio (LR) test is computed as the difference of model chi-square for the larger model (usually the initial default model) and a nested model (usually the result of model trimming), for one degree of freedom. LR measures the significance of the difference between two SEM models for the same data, in which one model is a nested subset of the other. Specifically, chi-square difference is the standard test statistic for comparing a modified model with the original one. If chi-square difference shows no significant difference between the unconstrained original model and the nested, constrained modified model, then the modification is accepted on parsimony grounds.

6.3.1.19. Output

6.3.1.19.1. Structural or Path Coefficients

Structural or Path Coefficients are the effect sizes calculated by the model estimation program. Often these values are displayed above their respective arrows on the arrow diagram specifying a model. In AMOS, these are labeled "regression weights," which is what they are, except that in the structural equation there will be no intercept term.

6.3.1.19.2. Standardized Structural (Path) Coefficients

When researchers speak of structural or path coefficients in SEM, they often mean standardized ones. Standardized structural coefficient estimates are based on standardized data, including correlation matrixes. Standardized estimates are used, for instance, when comparing direct effects on a given endogenous variable in a single-group study. That is, as in regression, the standardized weights are used to compare the relative importance of the independent variables. The interpretation is similar to regression: if a standardized structural coefficient is 2.0, then the latent dependent will increase by 2.0 standard units for each unit increase in the latent independent. In AMOS, the standardized structural coefficients are labeled "standardized regression weights," which is what they are. In comparing models across samples, however, unstandardized coefficients are used.

6.3.1.19.3. The Critical Ratio and Significance of Path Coefficients

When the Critical Ratio (CR) is > 1.96 for a regression weight, that path is significant at the .05 level (that is, its estimated path parameter is significant).

6.3.1.19.4. Goodness of Fit Tests

Goodness of fit tests determine if the model being tested should be accepted or rejected. These overall fit tests do not establish that particular paths within the model are significant. If the model is accepted, the researcher will then go on to interpret the path coefficients in the model ("significant" path coefficients in poor fit models are not meaningful).

6.3.1.20. Summary

This research employs Structural equation modeling (SEM) as the major analysis technique. Since SEM is a relatively new analysis technique in construction, an elaborate treatment of the mechanics of the SEM analysis technique was given in this section.

SEM grows out of and serves purposes similar to multiple regression, but in a more powerful way which takes into account the modeling of interactions, nonlinearities, correlated independents, measurement error, correlated error terms, multiple latent independents each measured by multiple indicators, and one or more latent dependents also each with multiple indicators.

Advantages of SEM compared to multiple regression that compelled the use of the former technique for this research include more flexible assumptions (particularly allowing interpretation even in the face of multicollinearity), use of confirmatory factor analysis to reduce measurement error by having multiple indicators per latent variable, the attraction of SEM's graphical modeling interface, the desirability of testing models overall rather than coefficients individually, the ability to model error terms, and ability to handle difficult data (non-normal data). Moreover, where regression is highly susceptible to error of interpretation by misspecification, the SEM strategy of comparing alternative models to assess relative model fit makes it more robust.

The following section describes and discusses the model developed in this research.

6.3.2. Model Description

As described earlier, SEM has two main components, a measurement component and a structural component. The measurement model describes how well various exogenous variables measure latent variables, i.e. it determines the relation between indicators and constructs, and enables the researcher to evaluate whether the constructs are measured with satisfactory accuracy. A confirmatory factor analysis is a measurement model, and determines how well various variables describe a factor or factors, or latent variables. The measurement models within a SEM incorporate estimates of errors of measurement of exogenous variables and their intended latent variable.

The second component of a SEM is the structural component. The structural model describes the relationships between latent variables (i.e. constructs), and is used to test and analyze the hypothesized relationships. SEM allows for direct, indirect, and correlative effects to be explicitly modeled, unlike standard regression models, which allow only for explicit modeling of direct effects. It is the structural component of SEM that enables the analyst to make substantive statements about the relationships between latent variables, and the mechanisms underlying a process or phenomenon. The structural component of SEM is akin to a system of simultaneous regression models.

SEM estimates parameters for both the links between measures (indicators) with their respective constructs (i.e., loadings) and the links between different constructs (i.e., path coefficients). The loadings can be interpreted as factor loadings, while the path coefficients are standardized regression coefficients. The explanatory power of the model can be tested by examining the sign, size, and statistical significance of the path coefficients between constructs in the model.

The nature of the links between constructs and measures (indicators) is referred to as an epistemic relationship. Two basic types of epistemic relationships are relevant to SEM—reflective indicators and formative indicators (Hulland, 1999; Mohamed, 2002). The indicators (questionnaire items) in the model were treated as reflective, as they were expected to covary. They were assumed to reflect the unobserved, underlying construct, with the construct giving rise to (or ‘‘causing’’) the observed measures. For example, constructs such as safety commitment and safety strategic concern are typically viewed as underlying factors that give rise to something that is observed. Accordingly, their indicators tend to be realized as reflective.

Anderson and Gerbing (1988) and Mohamed (2002) suggest that both the measurement model and the structural model should be assessed sequentially, as this two-stage approach reduces the likelihood of interpretational confounds because the validity of the constructs is established prior to investigating the hypothesized relationships. This is the approach followed in this research and is explained in the following sub-sections.

6.3.2.1. Assessment of Measurement Model

Prior to structural modeling, two measurement properties were examined to ensure that the data has a satisfactory level of reliability and validity (Fornell and Larcker 1981). The first of these is the individual item reliability, where loadings (or simple correlations) of the items on their respective constructs are assessed, using 0.70 as a cutoff point (Fornell and Larcker 1981). Exceeding this value simply implies that less than half of the item’s variance is due to error. Obtained values for items exceeded this threshold, with majority of loadings in the range of 0.75–0.90, demonstrating the satisfactory level of individual item reliability.

Convergent validity (also referred to as the homogeneity of the construct or composite reliability) is the second measurement property to be examined, and is evaluated by Cronbach's alpha. The Cronbach's alpha obtained for each construct is listed in Table 6.1. All constructs have acceptable convergent validity, as a value of 0.70 is usually accepted as the minimum desired value of the Cronbach's alpha (Litwin 1995).

Having satisfied the two measurement properties, it can be concluded that the constructs are measured with adequate precision.

Table 6.1: Convergent Validity of Independent Constructs

Construct	Cronbach's alpha
1. Safety commitment	0.923
2. Personal safety character and competence	0.865
3. Supportive work environment	0.853
4. Work pressure	0.872
5. Safety program	0.891
6. Safety strategic concern	0.897

6.3.2.2. SEM Specification

Numerous iterations were performed to arrive at a final SEM specification shown in Figure 6.6.

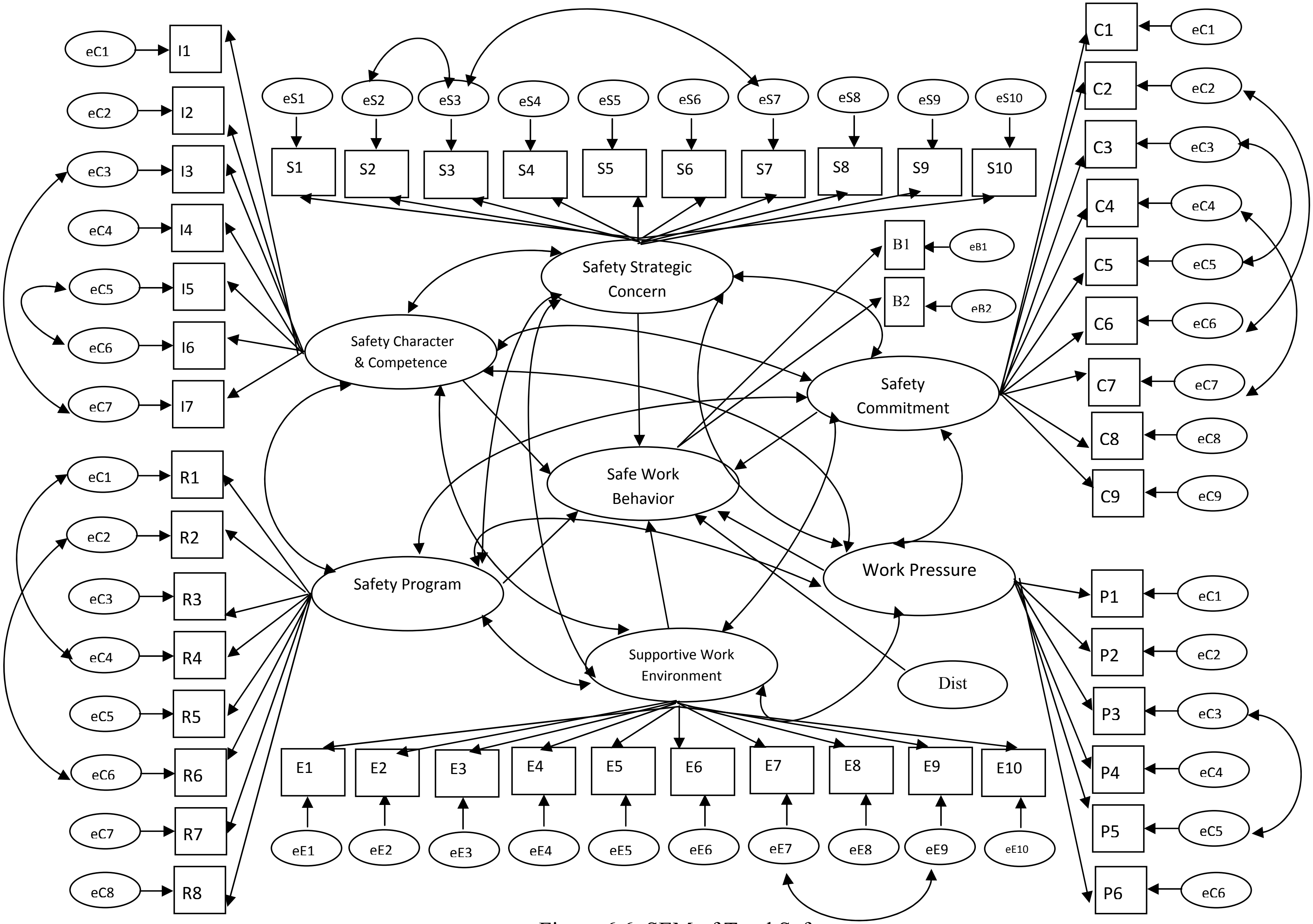

Figure 6.6: SEM of Total Safety

The observed or measured exogenous variables—responses to survey questions—are shown in the rectangular boxes in Figure 6.6. The unobserved constructs (latent variables) are shown in ellipses and represent the critical factors of safety dimensions, which cannot be directly observed. The arrows shown in Figure 6.6 represent the direction of hypothesized influence. For example, the straight single arrows connecting *safety commitment* to the nine exogenous variables (C1 to C9) are presumed to be the underlying mechanism that produced the outcomes of the observed variables (please note that the survey questions have been renumbered to correspond with the constructs for clarity as described below). Similarly, the other sets of questions are thought to reflect the influence of *safety strategic concern, personal safety character and competence, supportive work environment, safety program, work pressure,* and *safe work behavior* constructs on survey responses. The curved double-headed arrows linking the exogenous variables to each other represent the fact that these variables are correlated. The straight single arrows connecting the exogenous variables (*safety commitment, safety strategic concern, personal safety character and competence, supportive work environment, safety program,* and *work pressure*) to the endogenous variable *safe work behavior* imply causal relationship between the exogenous variables and the endogenous (dependent) variable. For simplicity, the standardized correlation coefficients are not shown on the figure. These are discussed later in this chapter.

The resultant six latent variables account for about 78% of the variability in safe work behavior (mean estimate of 0.78 and standard error =0.005). The overall SEM model results are given in Table 6.2 and the goodness of fit measures are given in Table 6.3.

Table 6.2: Overall SEM Model Results

Description	Result
Number of parameters estimated	126
Degrees of Freedom	1254
Chi square at model convergence	26.54, probability <0.10

Table 6.3: Overall SEM Model Results: Goodness-of-Fit Measures

Goodness-of-fit measure	Description of test	Saturated Model (Best case)	Final Model	Independence Model (Worst Case)
Number of parameters	Parameters estimated	192	126	60
Tucker-Lewis index (TLI)	0 (no fit) to 1 (perfect fit)	1.000	0.990	0.000
Normed fit index (NFI)	0 (no fit) to 1 (perfect fit)	1.000	0.982	0.000
Root mean squared error of approximation (RMSEA)	<0.05 indicates very good fit	N/A	0.042	0.735
Akaiki information criterion (AIC)	0 (perfect fit) to higher positive value (poor fit)	375	233	11,235
Browne-Cudeck criterion (BCC)	imposes a larger penalty than AIC for complex models: lower numbers means better fit	412	270	11,985

The model presented was the best-fitting model selected from many competing models that were fit to the data, all of which had solid theoretical support for their estimation. The chi-square value at model convergence indicates a good model fit. Associated with the chi square is the probability that the data were observed if the model were indeed well fitting, a probability of <10%. By taking into account the numerous other GOF measures for the SEM model, the model depicted in Figure 6.5 is a well-fitting model of safe work behavior and safety determinants. The equivalent of the *R-square* for the overall model ranges from 0.98 to 0.99, depending on the GOF criteria, the root mean squared error of approximation (RMSEA) is 0.042, where 0.05 cannot be rejected at a high level of confidence, and all other GOF measures are encouraging. The SEM appears to be a theoretically and statistically defensible model.

The initial SEM was constructed using various combinations of the factor analysis results and then model improvements were performed using a combination of modification indices (Hoyle, 1995; Molenaar et al., 2009) and solid theoretical support until a final satisfactory model was identified. In essence, asymptotic *t*-statistics and *R-square* goodness of fit (GOF) measures were employed to assess the regression equations in the model. The model development process is discussed in the section 6.3.2.4.

Both the measurement and structural components of the SEM provide insight into the influence of "total" safety determinants on safety performance. The measurement portion of the constructs and structural portion of the SEM are discussed in sections 6.3.2.5 & 6.3.2.6.

The next section validates that the model developed in the research was valid in terms of meeting the SEM assumptions. The section states the SEM assumptions and then the current research data/ model is analyzed to validate that the assumptions have been met.

6.3.2.3. Assessing the Validity of SEM Assumptions

6.3.2.3.1. A Reasonable Sample Size

According to James Stevens' Applied Multivariate Statistics for the Social Sciences, a good general rule for sample size is 15 cases per predictor in a standard ordinary least squares multiple regression analysis. Since SEM is closely related to multiple regression in some respects, 15 cases per measured variable in SEM is not unreasonable.

When data are not normally distributed or are otherwise flawed in some way (almost always the case), larger samples are required. It is difficult to make absolute recommendations as to what sample sizes are required when data are skewed, kurtotic, incomplete, or otherwise less than perfect. The general requirement is thus to obtain as much data as possible.

The sample size for the research in hand was 668, which is reasonable in view of the above discussion.

6.3.2.3.2. Continuously and Normally Distributed Endogenous Variables

SEM programs assume that dependent and mediating variables (Safe Work Behavior in case of the research in hand) are continuously distributed, with normally distributed residuals. However, this assumption is never completely met in practice.

SEM specialists have developed a number of methods (now inherently built into SEM software such as AMOS) to deal with non-normally distributed variables. These methods are designed for variables that are assumed to have an underlying continuous distribution; for instance, administering a Likert scale of items to research participants. The scale points tap into points along a continuum of scale, and even though the item data are not continuously distributed, the underlying distribution is continuous.

This research employed Likert scale of items and hence, in view of above discussion, trustworthy results are ensured.

6.3.2.3.3. Complete Data or Appropriate Handling of Incomplete Data

This assumption requires that the data set used as input for SEM analysis should not have any missing data value or, if so, the incomplete data must be appropriately handled (such as by using listwise deletion). In case of the research in hand, only complete data was utilized for the study.

6.3.2.3.4. Theoretical Basis for Model Specification and Causality

SEM models can never be accepted; they can only fail to be rejected. In most instances there are equivalent models that fit equally as well as the provisionally accepted model. Any of these models may be "correct" because they fit the data as well as the preferred model. The use of SEM thus entails some uncertainty, particularly with cross-sectional data that are not collected under controlled conditions. (This is also true of other commonly used models such as ANOVA and multiple regression techniques.) While models that fit the data well can only be provisionally accepted, models that do not fit the data well can be absolutely rejected.

In order to reach the "correct" model, the research employed evaluating competing models by using likelihood ratio chi-square tests to compare models, in addition to evaluating the absolute goodness of fit of single models.

The next section discusses the model development process.

6.3.2.4. Model Development Process

The model development process is illustrated in the schematic shown in Figure 6.7 and discussed below.

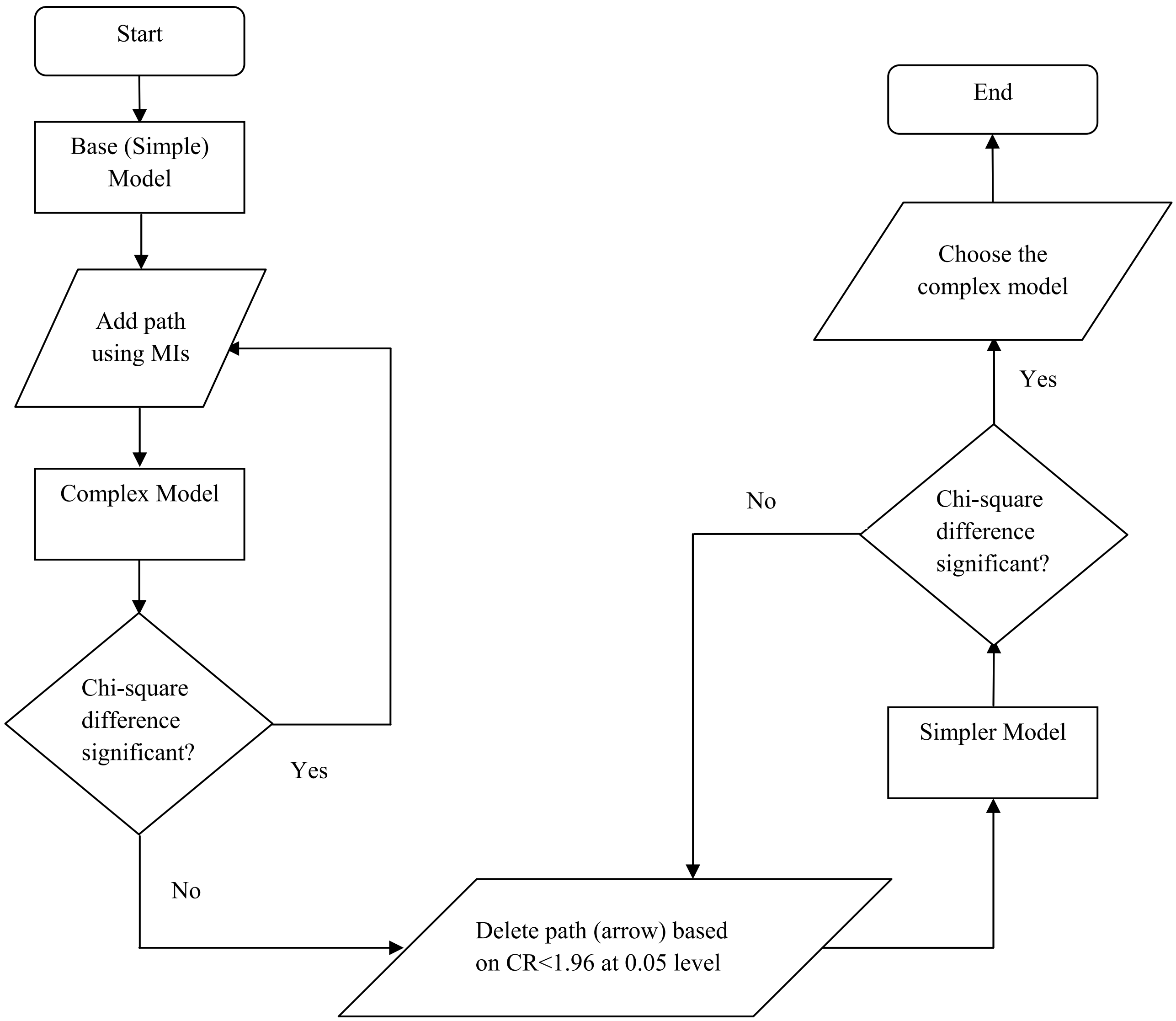

Figure 6.7: Model Development Process Flowchart

To arrive at the final SEM specification, model building strategy was employed starting with a simple model and adding paths one at a time, followed by model-trimming. As paths were added to the model, chi-square tended to decrease, indicating a better fit and also increasing the chi-square difference. That is, a significant chi-square difference indicated the fit of the more complex model was significantly better than for the simpler one. Adding paths was done only if consistent with theory and face validity.

Modification indexes (MIs) indicated when adding a path was improving the model. The strategy to use MIs was to add the parameter with the largest MI, then see the effect as measured by the chi-square fit index.

Using model building strategy, the model was first over-fit. Then one parameter was deleted at a time. That is, the researcher first added paths one at a time based on the modification indexes, then dropped paths one at a time based on the chi-square difference test. Modifying one step at a time was important because the MIs were estimates changed each step, as did the structural coefficients and their significance. In the overfit state, the model consisted of 85 indicators and 7 latent variables. The researcher then erased one arrow at a time based on non-significant structural paths, again taking theory into account in the trimming process. One focus of model trimming was to delete arrows which were not significant. The researcher looked at the critical ratios (CR's) for structural (regression) weights. Those below 1.96 were non-significant at the .05 level and the corresponding arrows were deleted.

Model trimming was continued until a significant chi-square difference indicated that trimming had gone too far. Note that a non-significant chi-square difference means that the researcher should choose the more parsimonious model (the one in which the arrow has been dropped). The goal was to find the most parsimonious model which was well-fitting by a selection of goodness of fit tests (Table 6.3), many of them based on the given model's model-implied covariance matrix not be significantly different from the observed covariance matrix. This is tantamount to saying the goal was to find the most parsimonious model which was not significantly different from the saturated model, which fully but trivially explained the data. After dropping a path, a significant chi-square difference indicated the fit of the simpler model was significantly worse than for the more complex model and the complex model was retained. Dropping paths was done only if consistent with theory and face validity. The final model consisted of 52 indicators and 7 latent variables. The six latent variables defining total safety constituted 50 indicators coming from various safety dimension subcategories (as shown in Table 6.4) and two indicators from the safe work behavior construct.

The model building and model trimming process involved comparing a model which was a subset of another. Chi-square difference was used because it was a hierarchical model. This is because model fit by chi-square is partly a function of model complexity, with more complex models fitting better.

In the case of modification indexes for covariances, two error term variables were allowed to correlate if the MI indicated substantial decrease in chi-square and the model was respecified to allow the error terms to covary. If there was correlated error, as shown by high MI's on error covariances, causes might include redundant content of the two items, methods bias (for example, common social desirability of both items) However, this was only done if strong theoretical evidence suggested as such.

The final model specification is as shown in Figure 6.6.

6.3.2.5. SEM Measurement Component

The measurement component of the SEM describes how accurately the various exogenous variables measure latent variables. The measurement models within a SEM incorporate measurements of exogenous variables with their associated errors to their

Table 6.4: Safety Dimension Subcategories Constituting the Model Constructs (Final Indicators)

Safety Dimension Subcategories \ Model Constructs	C	I	E	P	R	S	Total (Items in each subcategory)
Personal Intention & Commitment	1	1					2
Personal Value System	1	1					2
Personal Attitude & Perception	1						1
Personal Interpretation & Emotion		1		1			2
Personal Proficiency		3					3
Management Commitment & Involvement	2		1			2	5
Workers' Commitment & Involvement	1		1			1	3
Supervisory Commitment and Involvement	1		2	1		1	5
Subcontractor Commitment & Involvement			1			1	2
Communication			2			1	3
Safety Accountability			1			1	2
Production Pressure				3			3
Cultural Norms	1			1			2
Shared Values	1						1
Collective Beliefs/ Shared Understanding			1				1
Safety Rules and Procedures					3		3
Site Layout Planning			1		1		2
Safety Training and Education		1			2	1	4
Accident Investigation and Reporting					1	1	2
Safety Incentive Mechanisms						1	1
Safety Disincentive Mechanisms					1		1
Total (Items in each construct)	9	7	10	6	8	10	50

*C=safety commitment; I=personal safety character and competence; E=supportive work environment; P=work pressure; R=safety program; and S = safety strategic concern corresponding latent variable. The final six latent variables discovered to directly influence total safety are presented below. The latent variables are discussed in their order of influence on the endogenous latent variable *safe work behavior*. A more detailed interpretation of the latent variable effects on *safe work behavior* and their correlation among each other is presented in the following section describing the structural component of the SEM.

6.3.2.5.1. Safety Commitment

A company's *safety commitment* influenced the responses to 9 questions on the survey questionnaire. These variables span across 8 branches of the multiattribute hierarchy, including: personal intention & commitment (1), personal value system (1), personal attitude & perception (1), management commitment & involvement (2), workers' commitment & involvement (1), supervisory commitment & involvement (1), cultural norms (1), and shared values (1). All 9 variables share the common thread of the company's commitment to safety. The indicator "management acts decisively when a safety concern is raised" has highest squared multiple correlation (0.81). This can be interpreted as meaning that 81% of the variability in the observed variable can be explained by the latent variable, *safety commitment*, and the remaining 19% of the variability is unaccounted for and included in the error term. The indicators "management clearly considers safety to be more important than production" (0.78) and "workers play an active role in identifying site hazards" (0.77) are the next two most highly correlated variables.

The graphical representation of the latent variable and its components is shown in Figure 6.8. The numbers on the arrows are the squared multiple correlations. As previously described, *safety commitment* explains about 81% of the variability in C2, and *e*C2 explains other portions.

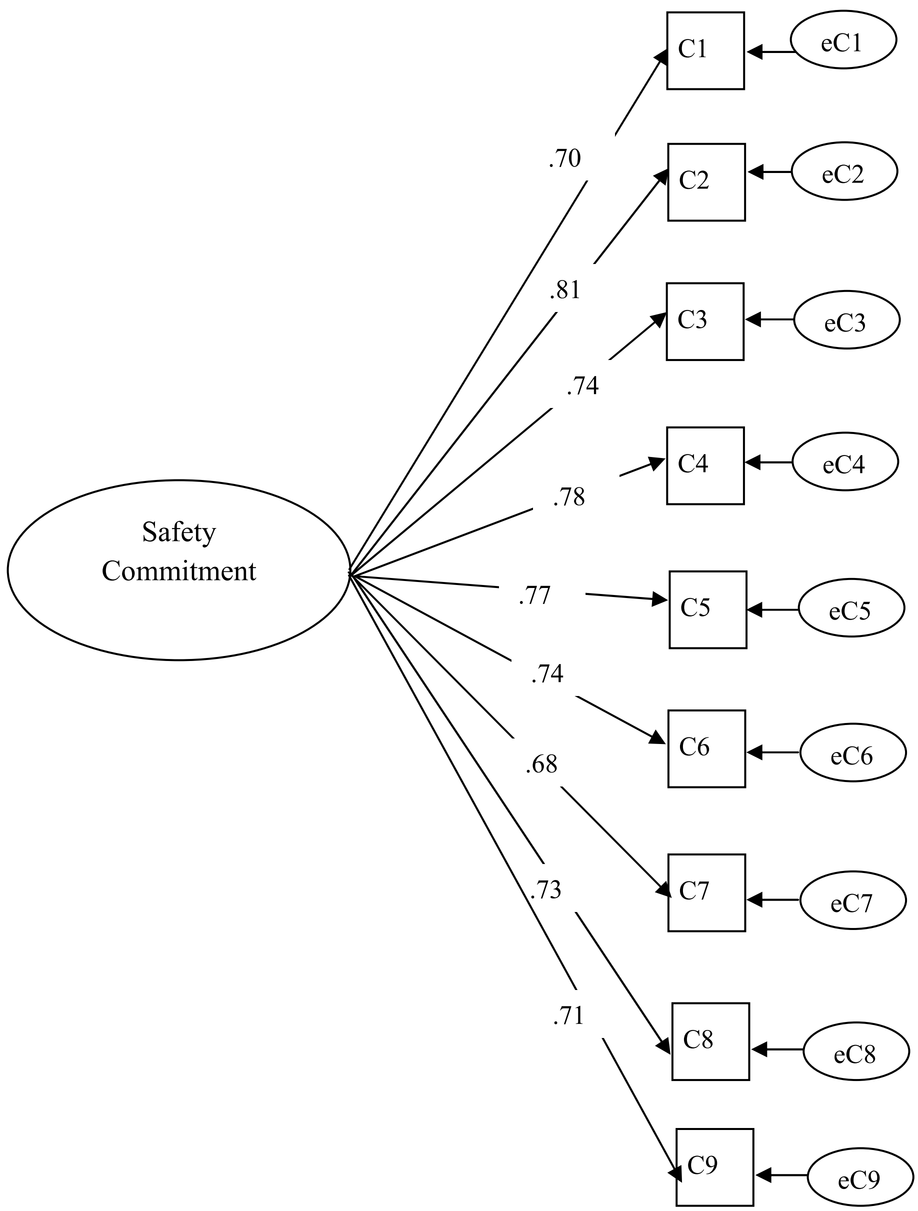

Figure 6.8: Safety Commitment

6.3.2.5.2. Personal Safety Character and Competence

The construct *personal safety character and competence* influenced the responses to 7 questions on the survey questionnaire. These variables span across 5 branches of the multiattribute hierarchy, including: personal intention & commitment (1), personal value system (1), personal interpretation & emotion (1), personal proficiency (3), and safety training & education (1). All 7 variables share the common thread of a person's safety character and competence. The indicator "I am capable of identifying potentially hazardous situations" has highest squared multiple correlation (0.84). This can be interpreted as meaning that 84% of the variability in the observed variable can be explained by the latent variable, *personal safety character and competence*, and the remaining 16% of the variability is unaccounted for and included in the error term. The indicators "I am positive that I can influence the level of safety performance" (0.80), "I believe safety is an integral value of my work performance" (0.78), and "I feel happy to behave safely" (0.77) are the next three most highly correlated variables.

The graphical representation of the latent variable and its components is shown in Figure 6.9. The numbers on the arrows are the squared multiple correlations.

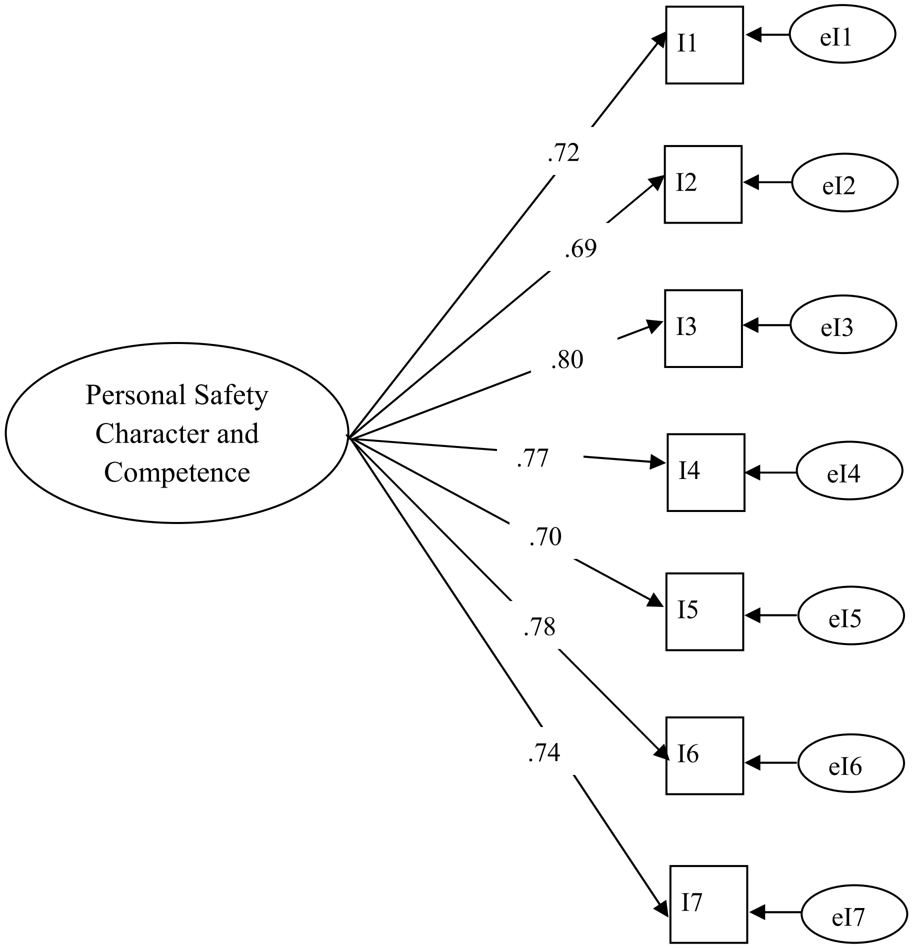

Figure 6.9: Personal Safety Character and Competence

6.3.2.5.3. Supportive Work Environment

A company's *supportive work environment* influenced the responses to 10 questions on the survey questionnaire. These variables span across 8 branches of the multiattribute hierarchy, including: management commitment & involvement (1), workers' commitment & involvement (1), supervisory commitment & involvement (2), subcontractor commitment and involvement (1), communication (2), safety accountability (1), collective beliefs/ shared understanding (1), and site layout planning (1). All 10 variables share the common thread of a supportive work environment. The indicator “my supervisor/safety manager has positive safety attitude” has highest squared multiple correlation (0.83). This can be interpreted as meaning that 83% of the variability in the observed variable can be explained by the latent variable, *supportive work environment*, and the remaining 17% of the variability is unaccounted for and included in the error term. The indicators “as a group, we endeavor to ensure that individuals are not working by themselves under risky or hazardous conditions” (0.79), “subcontractors proactively participate in site safety and hazard analysis” (0.77), and “suggestions to improve health and safety are acted upon” (0.75) are the next three most highly correlated variables.

The graphical representation of the latent variable and its components is shown in Figure 6.10. The numbers on the arrows are the squared multiple correlations.

6.3.2.5.4. Work Pressure

The construct *work pressure* influenced the responses to 6 questions on the survey questionnaire. These variables span across 4 branches of the multiattribute hierarchy, including: personal interpretation & emotion (1), supervisory commitment & involvement (1), production pressure (3), and cultural norms (1). All 6 variables share the common thread of work pressure. The indicator “under pressure safety rules should not be broken, even when worker believes it affects the production” has highest squared multiple correlation (0.82). This can be interpreted as meaning that 82% of the variability in the observed variable can be explained by the latent variable, *work pressure*, and the remaining 18% of the variability is unaccounted for and included in the error term. The indicators “under pressure I am not given enough time by my supervisor to get the job done safely” (0.80) and “under pressure it is an acceptable practice here to delay periodic inspection of plant and equipment” (0.78) are the next two most highly correlated variables.

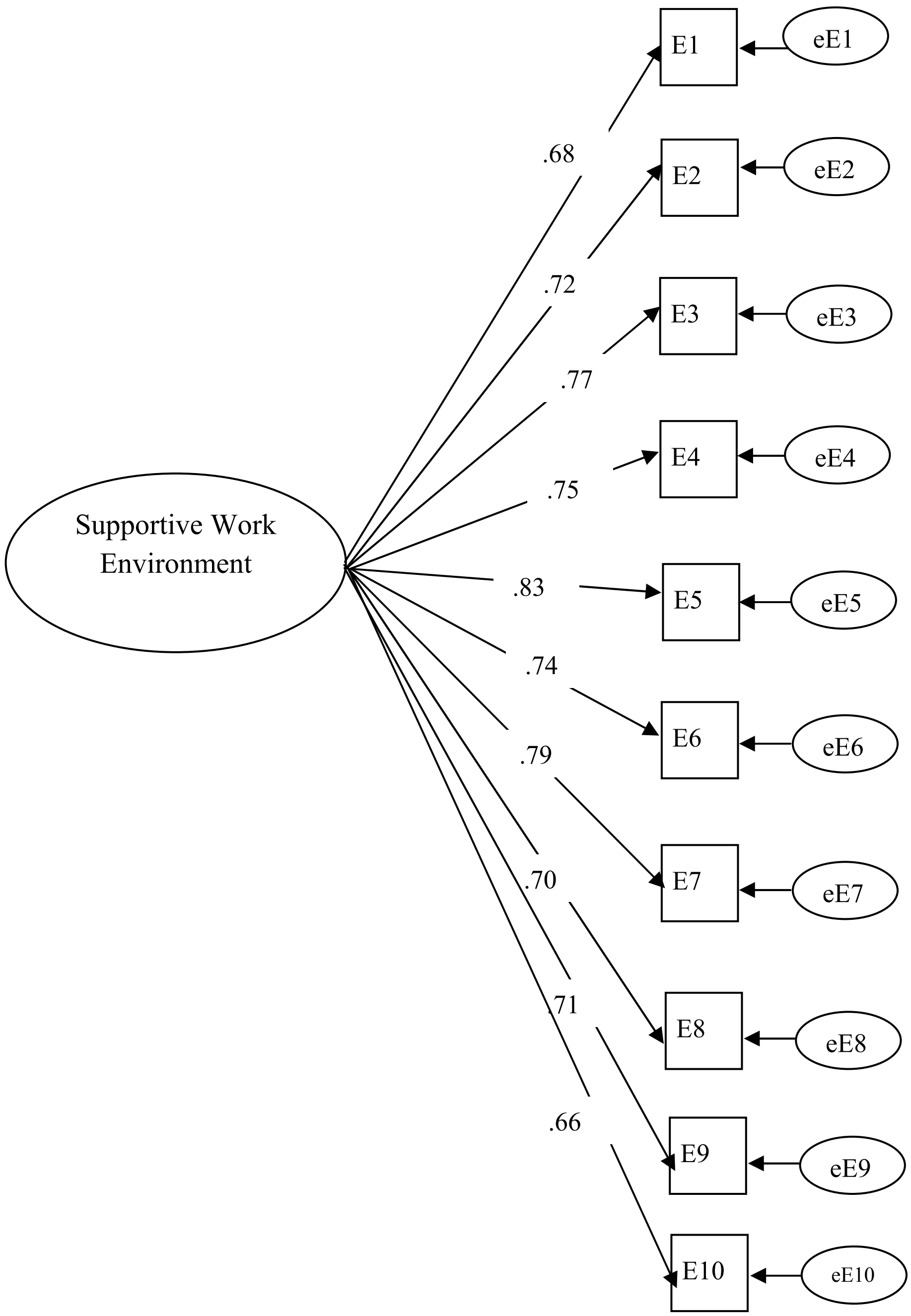

Figure 6.10: Supportive Work Environment

The graphical representation of the latent variable and its components is shown in Figure 6.11. The numbers on the arrows are the squared multiple correlations.

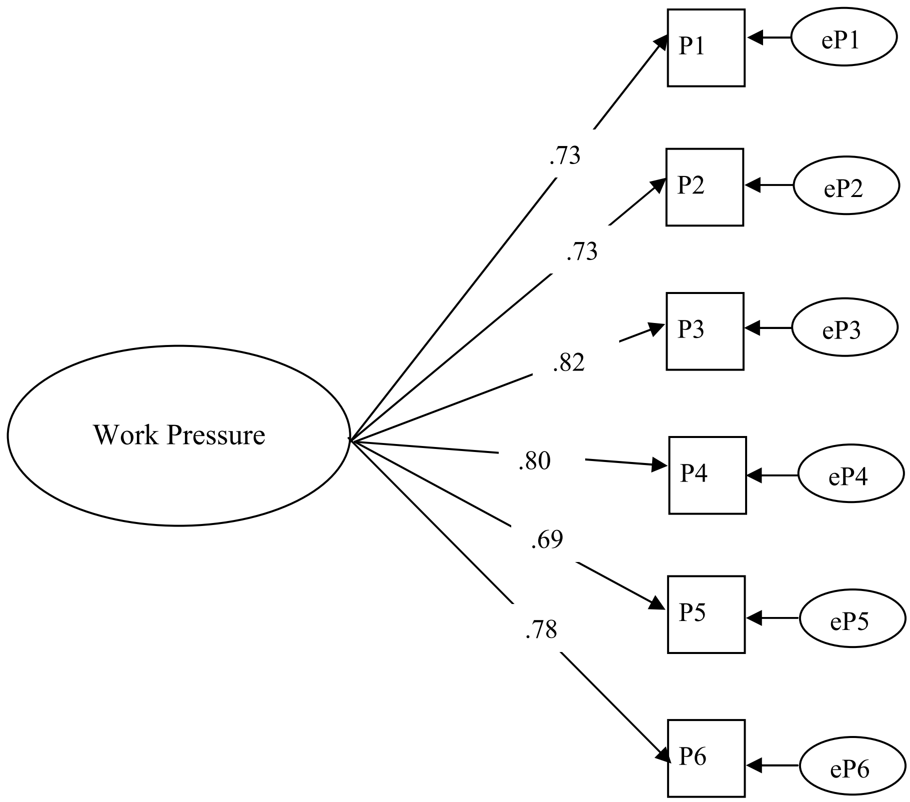

Figure 6.11: Work Pressure

6.3.2.5.5. Safety Program

A company's *safety program* influenced the responses to 8 questions on the survey questionnaire. These variables span across 5 branches of the multiattribute hierarchy, including: safety rules and procedures (3), site layout planning (1), safety training and education (2), accident investigation and reporting (1), and safety disincentive mechanisms (1). All 8 variables share the common thread of safety program. The indicator "Safety is a primary consideration when determining site layout" has highest squared multiple correlation (0.79). This can be interpreted as meaning that 79% of the variability in the observed variable can be explained by the latent variable, *safety program*, and the remaining 21% of the variability is unaccounted for and included in the error term. The indicators “current safety rules and procedures enforce the use of personal protective equipment whenever necessary” (0.78) and “accidents, incidents and near misses are required to be reported and investigated using a no-blame approach.” (0.76) are the next two most highly correlated variables.

The graphical representation of the latent variable and its components is shown in Figure 6.12. The numbers on the arrows are the squared multiple correlations.

6.3.2.5.6. Safety Strategic Concern

A company’s *safety strategic concern* influenced the responses to 10 questions on the survey questionnaire. These variables span across 9 branches of the multiattribute hierarchy, including: management commitment & involvement (2), workers’ commitment & involvement (1), supervisory commitment & involvement (1), subcontractor commitment & involvement (1), communication (1), safety accountability (1), safety training and education (1), accident investigation and reporting (1), and safety incentive mechanisms. All 10 variables share the common thread of strategic concern to safety. The indicator “management operates an open-door policy on safety issues” has highest squared multiple correlation (0.84). This can be interpreted as meaning that 84% of the variability in the observed variable can be explained by the latent variable, *safety strategic concern*, and the remaining 16% of the variability is unaccounted for and included in the error term. The indicators “safe behaviors are rewarded” (0.81) and “workers are held accountable if safety procedures are not adhered to” (0.78), and "lessons from accidents are communicated to workers to improve safety performance" (0.77) are the next three most highly correlated variables.

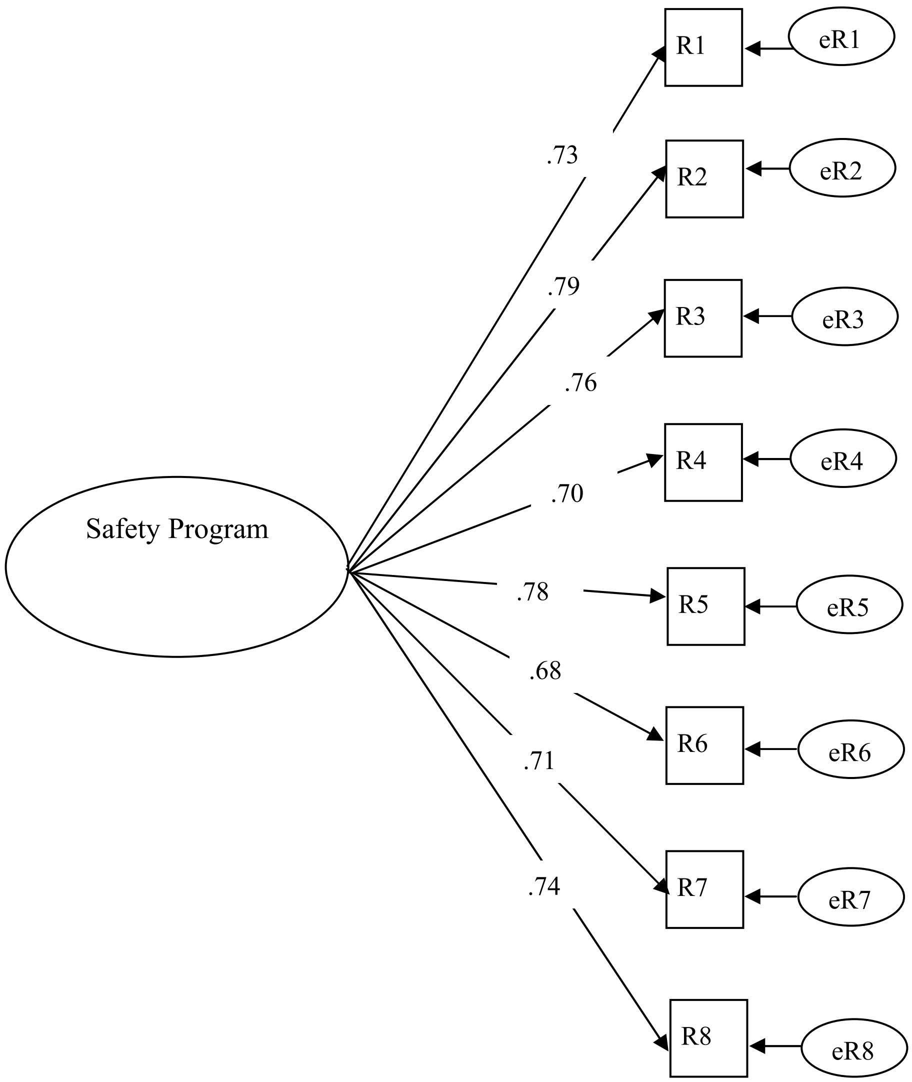

Figure 6.12: Safety Program

The graphical representation of the latent variable and its components is shown in Figure 6.13. The numbers on the arrows are the squared multiple correlations.

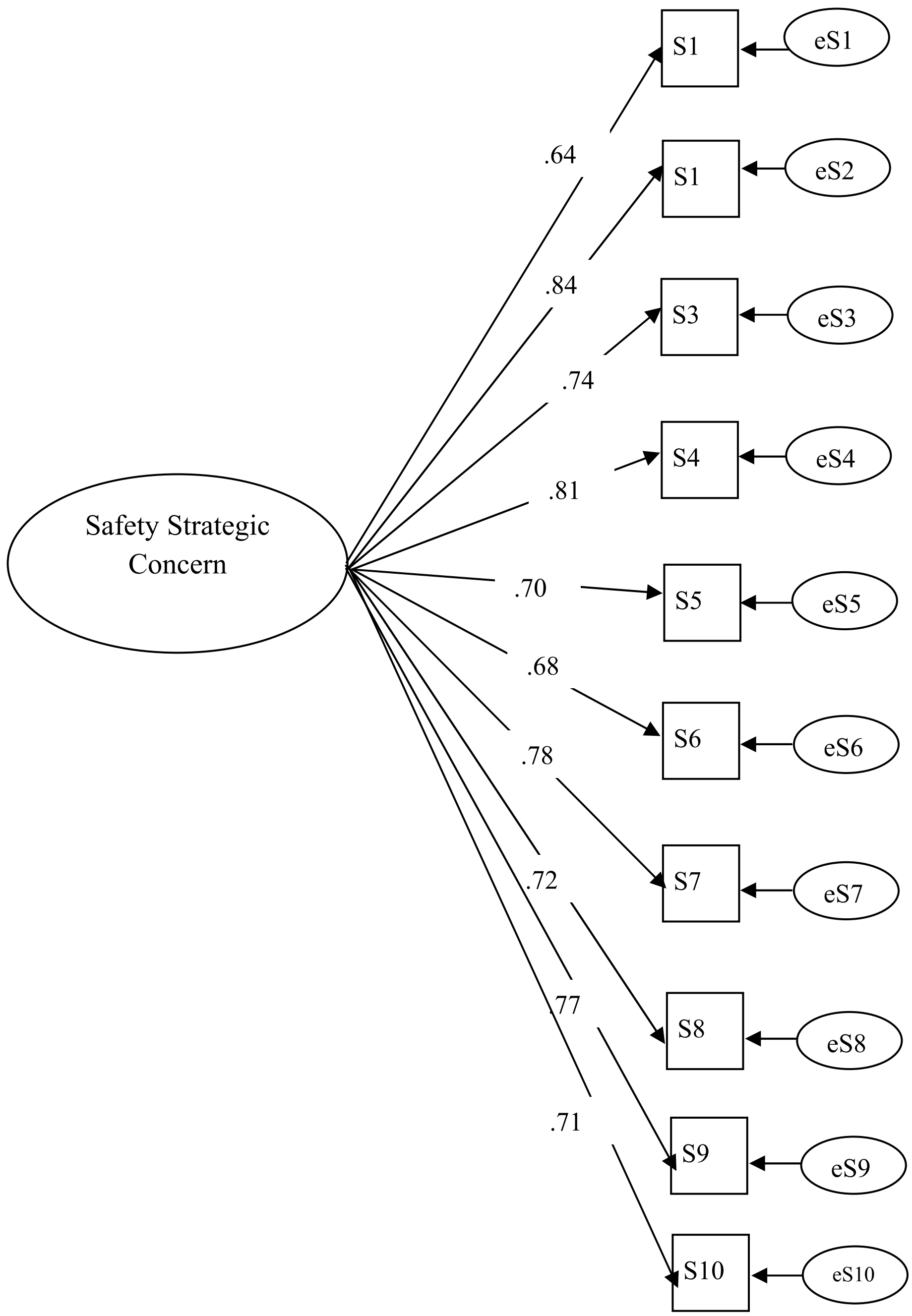

Figure 6.13: Safety Strategic Concern

6.3.2.5.7. Safe Work Behavior

The construct *safe work behavior* was used to measure safety performance. This construct influenced the responses to 2 questions on the survey questionnaire. These variables came from the behavior branch of the multiattribute hierarchy.

The graphical representation of the latent variable and its components is shown in Figure 6.14. The numbers on the arrows are the squared multiple correlations.

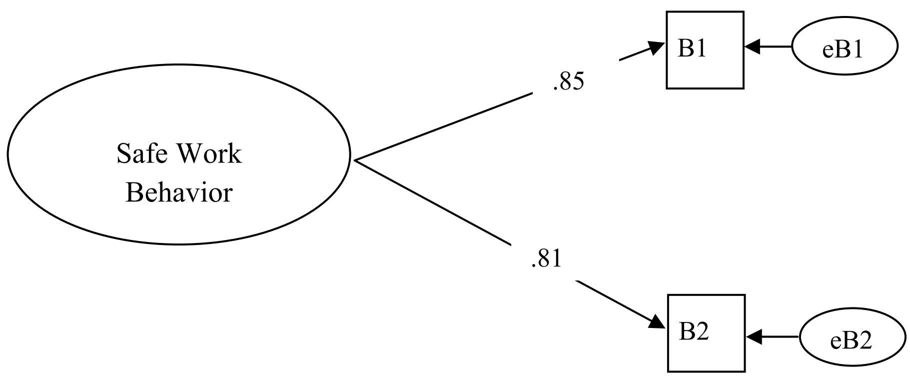

Figure 6.14: Safe Work Behavior

6.3.2.6. SEM Structural Component

This section presents the results of testing the research hypotheses. The structural component of the SEM explains the relationships between latent variables. SEM allows for direct, indirect, and correlative effects to be explicitly modeled, unlike standard regression models, which allow for explicit modeling of direct effects only. Figure 6.15 displays the structural component of the SEM. In this model, all latent variables are found to be correlated with safe work behavior, as well as all being correlated with each other. The numbers near the straight arrows are the standardized correlation coefficients obtained when an endogenous variable is regressed on the set of exogenous variables to which it is functionally related and the numbers by the curved arrows are the standardized correlation coefficients between each of the variables. A larger number can be considered a better indicator of the construct. Table 6.5 contains a summary of the hypotheses and the path coefficients obtained from the analysis.

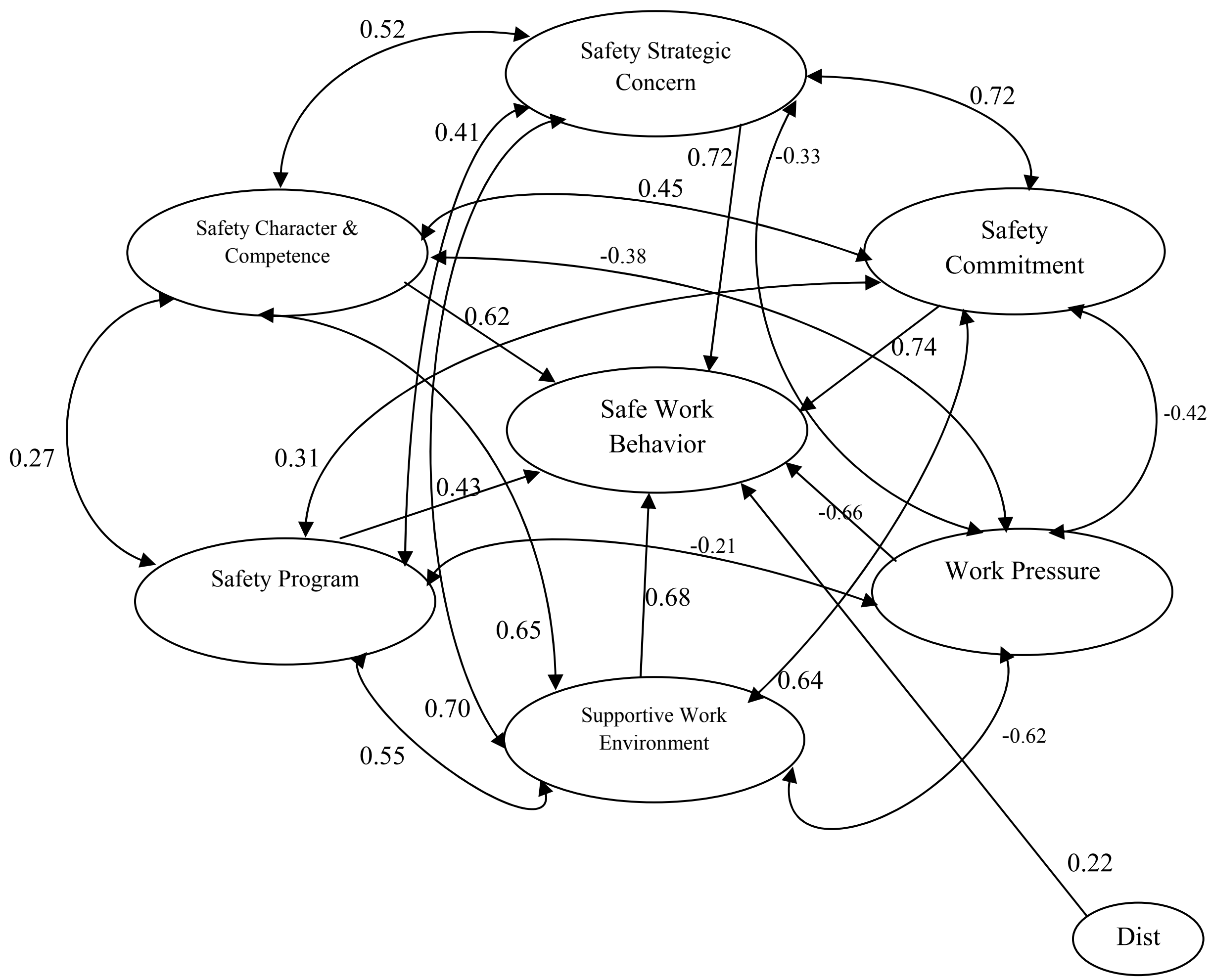

Figure 6.15: Structural component of SEM with correlation among variables shown

Table 6.5: Summary of Path Coefficients

Hypothesis and corresponding path	Expected sign	Path coefficient
H1: Greater company commitment = safe work behaviors	+	0.74
H2: Better safety character & competence = safe work behaviors	+	0.62
H3: More supportive work environment = safe work behaviors	+	0.68
H4: Higher perception of work pressure = unsafe work behaviors	-	-0.66
H5: Better safety program = safe work behaviors	+	0.43
H6: Higher safety strategic concern = safe work behaviors	+	0.72
H7: Higher level of total safety = safe work behaviors	+	0.78

As can be seen, all of the paths were in the direction hypothesized. The regression of the exogenous latent variables on the safe work behavior construct is a relatively high value of *R*-square of 0.98, or 98%. *R*-square can be interpreted in the same manner as that obtained for the multiple regression analysis. Thus, the model explains about 98% of the variance in the dependent construct safe work behavior for the sampled data. All of the path coefficients were statistically significant in the predicted direction, providing strong overall support for the hypothesized model. The majority of the total safety constructs affect safe work behavior. Safety commitment and safety strategic concern constructs have the strongest influence on safe work behaviors. Safety program has the least influence on safe work behaviors.

6.3.2.7. Discussion of Results

The structural component of SEM describes how the exogenous variables (the six total safety constructs) are correlated. This is discussed in the following subsection. Discussion of the hypotheses results is given in the next sub-section.

6.3.2.7.1. Correlation

Table 6.6 provides the standardized correlation coefficients between the dependent constructs. The interpretation of the highly correlated constructs is given in the following sub-sections.

Table 6.6: Standardized Correlation Coefficients

Construct	Construct					
	1	2	3	4	5	6
1. Safety commitment	-	-	-	-	-	-
2. Personal safety character and competence	0.45	-	-	-	-	-
3. Supportive work environment	0.64	0.65	-	-	-	-
4. Work pressure	-0.42	-0.38	-0.62	-	-	-
5. Safety program	0.31	0.27	0.55	-0.21	-	-
6. Safety strategic concern	0.72	0.52	0.7	-0.33	0.41	-

6.3.2.7.1.1. Safety Commitment

In this study, the *safety commitment* variable is highly correlated with the *safety strategic concern* (0.72) and *supportive work environment* (0.64), which can be interpreted as meaning that a company’s commitment is shown through safety strategic concern and provision of a supportive work environment.

6.3.2.7.1.2. Personal Safety Character and Competence

Personal safety character and competence is highly correlated with *supportive work environment* (0.65), which can be interpreted as meaning that personal safety character competence leads to a supportive work environment.

6.3.2.7.1.3. Supportive Work Environment

Supportive work environment is highly correlated with the *safety strategic concern* (0.70), *safety commitment* (0.64), *personal safety character and competence* (0.65), and *work pressure* (-0.62). The correlation of *supportive work environment* with *safety commitment* and *personal safety character and competence* has been previously described. The other two correlations can be interpreted as meaning that a company's supportive work environment is a reflection of its strategic concern and leads to improved perception of valuing expediency over safety.

6.3.2.7.1.4. Work Pressure

Work pressure is highly correlated with the *supportive work environment* (-0.62) as has been previously described.

6.3.2.7.1.5. Safety Program

Safety program is significantly correlated only with *supportive work environment* (0.55), which can be interpreted as meaning that a company's implementation of a safety program is positively reflected through a supportive work environment.

6.3.2.7.1.6. Safety Strategic Concern

Safety strategic concern is highly correlated only with *safety commitment* (0.72), *supportive work environment* (0.70), as has been previously described.

6.3.2.7.2. Hypothesis

The broad hypothesis is that safe work behaviors are consequences of the existing total safety environment, which, in turn, is determined by the six inter-dependent constructs—safety commitment, personal safety character & competence, supportive work environment, work pressure, safety program, and safety strategic concern. Strictly speaking, support was found for the influence of these six variables on safe work behaviors.

Hypotheses 1 dealt with company's safety commitment. The path from the commitment construct to safe work behaviors is the most significant. This implies that a company's *safety commitment* has the greatest influence on safety performance. This finding verifies previous research (Zohar, 1980; Mohamed, 2002; Molenaar et al., 2009) and further emphasizes the importance of company being committed to and involved in safety activities to emphasize safety issues within the organization. Hypothesis 6 dealt with safety as a strategic concern. The path from the safety strategic concern construct to safe work behaviors is also highly significant. This infers that companies where safety is part of their strategic policy and is treated as a strategic concern at all levels will inculcate safer work behaviors. Therefore, one can conclude that both commitment and strategic concern are prerequisites to achieving and sustaining zero accidents in construction site environments.

The result for hypothesis 3 suggests that supportive work environment has a significant positive impact on safe work behaviors. This is not very surprising, as a construction worker who continually interacts with coworkers and supervisors also relies on them to a greater extent to provide a safer work environment. These findings suggest that workers in more positive work environments are more likely to have above-average working relationships with managers, supervisors, and coworkers, and hence will have safer behaviors.

The structural model provides support for hypothesis 2 that personal safety character and competence are positively associated with safe work behaviors. This infers that personal commitment and proficiency are significant contributors to instilling safe work behaviors. Laukkanen (1999) reports that skilled and experienced construction workers have fewer stress symptoms and are less prone to hazards than the inexperienced ones.

The expected influence of work pressure on safe work behaviors (hypothesis 4) was supported, as the work pressure construct was significantly related to safe work behaviors. The negative correlation can be interpreted as meaning that an improvement in the perception of valuing expediency over safety correlates to an increase in company's safety performance as measured through a reduction in unsafe behaviors.

Safety program (hypothesis 5) has the least significant influence on safe work behaviors. This finding implies that the interior individual and collective pursuits of total safety (person and culture) have a significantly higher impact on safety performance (measured by safe work behaviors) as compared to the exterior pursuit of total safety (process). This result also strengthens the basic premise of this research, i.e. a systems approach to safety, by itself, is not enough to achieve the goal of zero accidents. Although this finding does not imply that safety program has no positive impact on safety performance, it does indicate that safety rules and procedures should play a complementary role and more safety improvement focus should be oriented towards improving the interior individual and collective pursuits leading to safe behaviors.

6.4 Comparison and Key Model Features

This section provides a brief description of safety models as reported in the literature in an attempt to highlight key features of the proposed model.

Grote and Kunzler (2000) presented a sociotechnical model of safety culture that links the safety management system and safety culture to the general organizational design. However, the model is more schematic and lacks any mechanism to improve and assess safety culture.

Geller (1994) provided a model distinguishing three dynamic and interactive factors, namely, person, behavior, and environment. Three years later, a total safety culture model, which included this safety triad and recognized the dynamic and interactive relationship between them, was proposed (Geller 1997). However, the model did not consider the process and system aspects of total safety. In addition, the model was based on lagging indicators for measuring safety performance.

Cooper (2000) argued that organizational culture is the product of multiple goal-directed interactions between people, jobs, and the organization, and presented a model recognizing the presence of an interactive or reciprocal relationship between psychological, situational, and behavioral factors. Again, the model did not consider the process and system aspects of total safety.

Building upon Geller's model, Cooper's argument, and broadening the organization construct into an environmental/situational construct to incorporate the safety system concept, the model presented by Choudhry et al. (2007) integrated three related concepts, namely, safety climate, behavior-based safety, and safety system, thus allowing different dimensions of construction safety culture to be measured individually or in combination.

This model provided allowance for a multilevel analysis of construction safety culture. However, the model did not examine the degree to which safety management systems actually influence people's behaviors. Furthermore, the study did not delve into the interaction between safety climate, safety management systems and safety-related behaviors.

Molenaar et al. (2009) developed a structural equation model of corporate culture as it affects safety performance. This research was based on the hypothesis that construction safety performance (measured by EMR – Experience Modication Rating) is predictable on the basis of corporate safety culture. The research proposed that construction organizations can have inherent characteristics that predispose them to be susceptible to accidents. The characteristics that influence corporate safety culture were classified into three main categories: (1) people; (2) process; and (3) value. The primary results of the study can be summarized by stating that corporate safety culture is significantly related to safety performance. From an integral strategic perspective of safety, the limitations of this research study were: 1) the study only looked at the "culture" domain of the fundamental domains defining total safety; 2) the study used a lagging indicator (EMR) to measure safety performance; and 3) the data collected to develop the model was limited. The research in hand attempts to overcome these limitations and builds upon a large data set, considers an integral view of all fundamental total safety dimensions (person, culture, behavior and process), and uses a leading indicator (safe work behavior) to measure safety performance.

Mohamed (2002) examined the relationship between the safety climate and safe work behavior in construction site environments. This study also utilized the technique of structural equation modeling to come up with a relationship model between safety climate determinants and safety performance (as measured by safe work behaviors). From an integral strategic perspective of safety, the limitations of this research study were: 1) the study looked at the "culture" (in fact climate) and the "behavior" domains of the fundamental total safety dimensions; 2) the study ignored interaction effects between the factors determining the safety climate; and 3) the study was only based on data collected from construction workers and did not take into account the perspectives of top management and supervisors. The research in hand attempts to overcome these limitations and builds upon an integral view of all fundamental total safety dimensions (person, culture, behavior and process), considers the interaction effects between the factors determining total safety, and basis itself on a large data set with data collected from top management, supervisors, foremen, and construction workers.

While all above models were intuitive and addressed safety from a cultural, climate or behavior-based perspective, they still lacked a total approach to safety i.e. an approach that would take into consideration the entire personal, group, behavioral, process and production system factors as an integrated model determining the true total safety performance of a construction organization. Secondly, objective measurement and improvement of total safety (as identified by all dimensions defining and determining total safety) remained a concern to be addressed. Thirdly, most of these models were based on lagging safety performance indicators (such as EMR) and were also limited in terms of data utilized for the studies.

Building upon previous models (specifically, Molenaar et al., 2009 and Mohamed, 2002), the model presented in this research has the following key features:

1. It integrates all the fundamental dimensions of total safety, namely, person, culture, behavior, and process, thus allowing different dimensions of construction total safety to be measured individually as well as in combination.
2. The four constructs complement each other in a way that offers an integral measurement model, thus allowing for a multiattribute hierarchy analysis of construction total safety determinants.
3. The measurement model considers the interaction effects between the constructs determining total safety as well as the integral effect of all the total safety dimensions on construction safety performance.
4. The model incorporates a leading indicator of safety performance, viz. safe work behavior, which allows measurement of true safety performance of a construction organization because it does not base itself on retrospective accident statistics.
5. The model is build upon data collected from various tiers of a construction organization, including workers, foremen, supervisors, project managers and corporate managers, and hence provides a more comprehensive and realistic measurement mechanism of total safety.
6. The model is fundamental and very simple in nature and allows a self-evaluation and self-improvement mechanism based on fundamental total safety determinants.
7. Since the model is based on the statistical tool of structural equation modeling, it caters for the interaction between independent variables as well

as takes into account the measurement and model errors, and hence provides a more realistic assessment of total safety.

6.5 Conclusion

This chapter discussed the development of a strategic safety improvement model based on SEM analysis on the underlying total safety determinants. The model provided the correlation between the factors determining total safety and their influence on a company's safety performance as measured by a leading indicator of safe work behavior. This constituted achieving objectives 3 of the study.

From data collected in phase II of the research (chapter 6), a research base model was first developed. Following this, a structural equation model (SEM) was estimated to identify latent constructs that describe total safety and to quantify relationships among them and between these total safety determinants and safety performance of a construction organization. Finally, the strategic framework was presented along with a discussion of the key components of the framework and their utility towards strategically improving safety in the construction industry.

The total safety model presented in this chapter provides a framework for continuous measurement and improvement of safety. From a practical perspective, this model approaches safety as a total process taking into consideration the interior and exterior individual and organizational characteristics that determine the true safety environment of a company and provide a quantitative framework to better understand and evaluate total safety performance of construction industry. Since this model is fundamental in nature and addresses safety from an integral perspective taking into account the personal, organizational, behavioral and process perspectives collectively, it has the potential to strategically achieve and sustain the goal of zero accidents.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Research Summary, Conclusions and Contributions

The research in hand had three key objectives: 1) to assess the current state of safety in the construction industry and establish the need for addressing safety as a total process in construction contracting organizations; 2) to identify the factors determining the total safety environment of a construction contracting organization, which are most suitable and appropriate for measurement and improvement and hence play a pivotal role in strategic safety improvement; and 3) to develop a strategic framework for defining, measuring, and improving total safety in the construction industry in order to achieve and sustain the goal of zero accidents. To achieve the above objectives, the research endeavor was undertaken in two distinct phases. Phase I of the research, which was consistent to achieving objective of the study, concluded that the present safety management practices in the construction industry have failed to deliver well on the following areas of safety performance:

1. Strategic vision of safety,
2. Strategic approach to safety improvement,
3. Employee involvement and empowerment,
4. Organizational readiness to embrace Total Safety Management,
5. Safety communication and decision making,
6. Safety commitment and support,
7. Maintaining a positive attitude towards safety,

8. Worker motivation,
9. Accident investigation and reporting, and
10. Safety training and orientation

In addition, it was also concluded that OSHA, the lead regulatory agency driving safety, is not performing at par in terms of achieving strategic safety improvement in the construction industry and needs to improve on its vision and approach towards safety. OSHA's strategic approach, as reflected from the findings, should be "continuous improvement through positive reinforcement" as against "inspection and penalty" approach. Moreover, it was concluded that OSHA would need to work with the companies and not against them in order to achieve the strategic goal of zero accidents in the industry.

Based on the findings of Phase I of the research endeavor, the major conclusion drawn was a dire need of a framework that would allow the industry to strategically and continuously improve safety in order to attain and sustain the goal of zero accidents. Such a framework would be particularly instrumental in generating a total safety environment in the industry, which would promote safety for the sake of safety and not for the safe of "compliance" or "penalty avoidance". This framework would require an integral approach to safety with commitment and participation from all levels as well as sectors of the industry.

Following phase I of the research study, an integral model of total safety was adapted from literature, which formed the basis of phase II of the research undertaken to achieve objective 2 of the study. The integral model allowed decomposition of total safety into four principal dimensions, viz., person, culture, behavior and process, which were further decomposed into 83 measurable attributes using a multiattribute analysis technique. These formed the basis of a questionnaire to measure total safety. Safe work behavior was selected as a measure of a company's safety performance for the study. Based on the survey responses, statistical relationships between total safety dimensions and safety performance (measured by safe work behavior) were revealed through a series of six latent variables (factors) that describe the total safety environment of a construction organization.

These six factors (and their corresponding indicators) formed the basis of developing a strategic safety improvement model for the construction industry consistent to achieving objective 3 of the study. The research base model followed the broad hypothesis that safe work behaviors (and, thus, their reciprocal, unsafe behaviors) are consequences of the existing total safety dimensions in a construction organization, which is determined by the six factors (and their corresponding indicators) already identified. A structural equation model (SEM) was estimated to model the latent constructs that describe total safety and to quantify relationships among them and between these total safety determinants and safety performance of a construction organization. Model constructs and associated hypotheses were appropriately defined and, after numerous iterations, a final SEM specification was reached.

Total safety is extremely complex to define and measure as displayed though both the multiattribute hierarchy and the multiple interrelationships of the SEM estimated in this research. However, the SEM and the latent variables it describes constitute a powerful framework for defining, measuring, and improving total safety. Analysis of data from the 83 measurable characteristics revealed that 50 could be used to describe a final set of six latent variables. These six latent variables can be considered characteristics of total safety and may be used as indicators of safety performance as measured through safe work behaviors.

The total safety model developed provides a framework for continuous measurement and improvement of safety in the construction industry without adding complexity and administrative burden. From a practical perspective, this model approaches safety as a total process taking into consideration the interior and exterior individual and organizational characteristics that determine the true safety environment of a company and provide a quantitative framework to better understand and evaluate total safety performance of construction industry. Since this model is fundamental in nature and addresses safety from an integral perspective taking into account the personal, organizational, behavioral and process perspectives collectively, it has the potential to strategically achieve and sustain the goal of zero accidents.

Specifically, the research has provided the following contributions:

1. A framework showing the interrelationships among the factors defining total safety and the relationship of these factors with the true safety performance of a construction organization
2. The formulation and quantification of the interrelationships mentioned above to facilitate measurement of total safety
3. A strategic tool providing a framework for continuous measurement and improvement of total safety.
4. A strategic tool giving the construction participant a clear picture of the true safety performance of the company, but would also suggest the individual,

organizational, and process characteristics that need to be improved for sustained improvement on total safety.

7.2 Strategic Industry Benefits

The researcher foresees the developed framework to be used as a tool by the industry personnel to continuously improve safety in their organizations. It would not only give the construction participant a clear picture of the true safety performance of the company, but would also suggest the individual, organizational, and process characteristics that need to be improved for sustained improvement on total safety.

Specifically, the developed strategic safety improvement framework can provide the following benefits to the industry.

1. The current financial crisis has put the role of safety management in the construction business into focus. For U.S. firms engaging themselves in the construction business, one of the most effective means of mitigating financial risks is through a strategic safety management model. The developed framework can be adopted by U.S. contractors and subcontractors to measure and continuously improve their safety performance and hence achieve the goal of zero accidents.
2. The developed framework can be adopted by OSHA to devise strategies for safety measurement and improvement in the construction industry on sustainable basis. Since this model is based on an integral approach to safety, it is deemed to have the adaptability to implement itself in the existing safety management systems and hence will help induce a sustainable safety culture in the construction industry.

3. The developed framework can be adopted by construction owners to devise strategies for evaluating the safety performance of construction contractors (at the bidding stage or otherwise), who will now have the opportunity to present their firm-specific safety strategies based on their own safety performance levels.
4. The developed framework may largely reduce the administrative over-burden for safety regulatory bodies (OSHA), owners, contractors and subcontractors by providing a self-evaluation and self-improvement mechanism for safety based on process measurement. Of course, this is not to say that this framework will eliminate the requirement of monitoring the safety performance of contractors and subcontractors from a regulatory perspective – the mechanism will now be more powerful and less cumbersome because it will be focusing on safety as a total process rather than focusing on unsafe outcomes (accidents).
5. Since this framework is integral for implementing safety as a total process in the construction industry, strategically, it may prove to be a best value system for the industry. That is, the model, if successfully implemented, will not only improve the safety performance of the construction industry, but will also help the industry become more competitive and productive; hence providing best value to its customers.
6. Although the framework has focused on the U.S. construction industry commercial building sector, the nature of the model makes it suitable to any sector of construction industry around the globe. This is particularly because

the model was based on well-established principles and was focused on total process measurement and improvement, both of which are independent of the particular industry in which the model will be functional.

7. It is envisaged that this research effort will immensely contribute to the development of education and training programs in construction safety, as this model will help provide a strategic insight into the aspects to be included in long-term and effective safety education and training programs. The very premise (and the results) of this model provides a shift of focus from treating safety as a systems approach to approaching it as a total (individual and group) process that integrates personal and collective values, beliefs, commitments, attitudes, perceptions, interpretations, emotions and understandings.

7.3 Recommendations

This SEM suggests that total safety dimensions are important determinants of safety performance. The six characteristics described by the latent variables in the SEM may be interpreted as action items that companies can use to improve their total safety environment and their safety performance. Each latent variable can be summarized as a total safety characteristic with corresponding action items that may improve safety performance as follows:

Increase a company's ***safety commitment***:

- Actively participate in safety;
- Clearly emphasize on safety to be more important than production;
- Involve workers in proactively identifying site hazards;

- Obtain commitment from all the supervisors and key people to incident and injury free. (This may be done in orientation sessions and in the field.)
- Identify and correct the causes of unsafe actions before they get translated to accidents.
- Recognize those people who have demonstrable success in safety and people skills.
- Encourage and reward those who "step out of the box" and take initiative.
- Attempt to create the right attitude in those who need a little coaching.
- Encourage coaching within crafts and across craft lines.
- Post signs with Safety slogans on all drinking water cans and in conspicuous places throughout the worksite. Move signs around.
- Have Staff through Front Line Supervisors participate in High Performance Safety Sessions.
- Have all Craftsperson's and Helpers participate in High Performance Safety Meetings without any supervisors present.

Increase a company's ***safety strategic concern***:

- Maintain an open-door policy on safety issues (offer opportunities for all personnel to provide feedback regarding safety concerns;
- Reward safe behaviors (create an understanding that field employees will be recognized for safe performance);
- Strengthen accountability measures at worker level; and

- Effectively communicate lessons from accidents to improve safety performance of workers.
- Acquire and retain those people who have exposure to the injury/ incident free initiative.
- Retain those people with the right attitude.
- Treat the workforce to refreshments on occasion to reward them for a good job and to help keep morale and awareness elevated.
- Canvass other jobsites for ideas that would help keep awareness and enthusiasm where it should be.
- Encourage everyone to mention something regarding Safety in every conversation. It does not have to be lengthy or sophisticated, just enough to keep awareness up.
- Share with employee's info from the weekly HSE report from the company to heighten awareness of things to prevent.
- Encourage the working population to focus on Safety one hour at the time. Be sure that Management has furnished them all that it takes to do that.
- Keep a team intact to continue to work on barriers and solutions.
- Share with other sites those things that work for yours.

Improve ***individual safety character and competence***:

- Increase individual capability of identifying potentially hazardous situations;
- Encourage individuals to positively influence the level of safety performance;
- Instill safety as an integral value of work performance; and

- Encourage safe behaviors.
- Offer coaching.
- Have Staff members greet employees as they come in each morning.

Improve a company's ***supportive work environment***:

- Continuously emphasize on supervisors to maintain a positive attitude towards safety;
- Encourage workers to ensure that individuals are not working by themselves under risky or hazardous conditions;
- Encourage subcontractors to proactively participate in site safety and hazard analysis;
- Create long-term relationships with subcontractors; and
- Promptly act upon suggestions to improve health and safety.
- Have project manager, superintendents and supervisors visible in field as well as accessible to the working population.
- Hold job wide safety meetings on a monthly basis. Solicit some of the topics from the workforce. Involve some speakers from the workforce.
- Establish a Project Manager's Safety and Quality Advisory Team with representation from each craft. Have periodic meetings. Act on recommendations. Provide feedback.
- Encourage all supervisors to communicate their concern for and interest in each member of the workforce.

- Establish a Front Line Supervisor's forum. Meet on a periodic basis to discuss needs, concerns, suggestions for improvement and new developments.
- Make visible the fact that the Project Manager and the Safety Manager are working closely together to manager the project.

Improve a company's ***safety program***:

- Ensure that safety is a prime concern in site layout planning;
- Enforce the use of personal protective equipment;
- Ensure that accidents, incidents and near misses are reported and investigated using a no-blame approach; and
- Provide safety training emphasizing on identifying potential risks and consequences.
- Assure that job plans include plans for the safe execution of work assignments.

Improve the ***perception of valuing expediency over safety***:

- Demonstrate clear commitment that safety rules should not be broken, even when worker believes it affects the production;
- Emphasize on supervisors to value safety over productivity; and
- Emphasize on supervisors to periodically inspect plant and equipment, even under production pressure.

7.4 Limitations

Three potential limitations of the current research study, which are also suggestive of future research paths, deserve attention. First and foremost, as with most research surveys, the data collected were partly self-reported; hence, some of the relationships may be exaggerated due to common method bias. Available information from top management and supervisors was used to reduce the bias, in particular, in matters concerning management commitment, communication, and the supervisory environment.

A second limitation is that the scope was limited to general and specialty contractors working in the building construction sector only. However, this is not really a limitation because the fundamental nature of the model allows it to be used for other sectors in other industries as well.

A third limitation is that the questionnaire was distributed only in English. Although a reasonable sample from each company was achieved at the upper management, middle management, and field levels, non-English speaking employees did not complete the survey. In the future, a computer survey could be considered with multiple languages, leading to automation and expediency of the data collection process. Employees without access to computers would still require paper-based questionnaires.

Despite the stated limitations, this research shows that total safety can be quantified and is related to safety work behaviors. The methodological framework presented in this paper provides a new set of tools for identifying and measuring total safety. The recommendations from this research are based on findings of this study. As more data are collected and new variables are observed, these results may be further refined; however, this research serves as a fundamental advancement in the industry's understanding of total safety and its correlation to safety performance.

7.4 Future Research Directions

The next step in the research could be to expand the data collection and develop the framework into a "thermometer" of total safety environment. By automating the process via computer, companies could distribute this questionnaire to all their employees and quickly measure their total safety environment. Just as a poor cholesterol test identifies increased risk of a heart attack, a poor total safety environment test would indicate increased risk of an impending accident. More importantly, the test would help to identify aspects of total safety needing improvement.

More formally, a tool to predict the likelihood of construction accidents, the accident potential index (API) can be developed based on the strategic model developed herein. No such tool is currently available in the construction safety research, although use of such tools has been seen in other areas of construction research such as construction disputes, wherein a dispute potential index (DPI) has been in use since 1994 to predict the likelihood of legal disputes (Diekmann and Girard 1995). The API would be a predictive tool designed to identify the presence of problem-prone characteristics in the safety performance of a construction company, measure them, and report the results to the participants in the company so they can take corrective action to prevent accidents.

The API would consist of a self-administered questionnaire asking a company leader to answer critical questions about the total safety dimensions in the company. A computer program may process the answers, analyzes them, and calculates two sets of numbers:

- first, an overall numerical rating indicating generally whether the company is likely to fall into the good, bad, or average range with respect to overall potential for accidents; and
- second, an individual score for each of six key total safety determinants, to identify particular areas of the company that have the greatest potential for breeding unsafe behaviors.

Appendix A – Survey Instrument 1

Assessment of Current Safety Attitudes and Approaches of Contractor Top Management in the U.S. Construction Industry

(To be filled by Contractor Top Management/ Office Management, e.g. CEO, Operations Manager, Safety Director, Project Director, etc.)

NOT TO BE FILLED BY ANY SITE RELATED PERSONNEL

All the information gathered here will be kept strictly confidential and will be used only for research and analysis without mentioning the person or company names. Thank you very much for your cooperation.

Personal Information (Optional)

Name of Respondent: ____

Present position in the company: ____________________________________

Total work experience: ___________ years

Work experience in this company: __________ years

Please provide contact info if you like to be contacted again regarding this questionnaire:

____

Company Information

Company Name: ____

Company Location (City & State): __________________________________

Type of Company (Contractor Trade):

- ☐ General Contractor (GC)
- ☐ Poured Concrete Foundation and Structure Contractor
- ☐ Structural Steel and Precast Concrete Contractor
- ☐ Framing Contractor
- ☐ Masonry Contractor
- ☐ Glass and Glazing Contractor
- ☐ Roofing Contractor
- ☐ Siding Contractor

- ☐ Electrical Contractor
- ☐ Plumbing, Mechanical & HVAC Contractor
- ☐ Drywall and Insulation Contractor
- ☐ Painting and Wall Covering Contractor
- ☐ Flooring Contractor
- ☐ Tile and Terrazzo Contractor
- ☐ Finish Carpentry Contractor
- ☐ Site Preparation Contractor
- ☐ Other ___________________________

Approx. company size (no. of persons): _________ (admin) ________ (technical)

Number of Years in Business: ___________

Approx. annual turnover (in millions): ______________

States of operation (Check all that apply):

- ☐ Alabama
- ☐ Iowa
- ☐ Alaska
- ☐ Kansas
- ☐ Arizona
- ☐ Kentucky
- ☐ Arkansas
- ☐ Louisiana
- ☐ California
- ☐ Maine
- ☐ Colorado
- ☐ Maryland
- ☐ Connecticut
- ☐ Massachusetts
- ☐ Delaware
- ☐ Michigan
- ☐ District of Columbia
- ☐ Minnesota
- ☐ Florida
- ☐ Mississippi
- ☐ Georgia
- ☐ Missouri
- ☐ Hawaii
- ☐ Montana
- ☐ Idaho
- ☐ Nebraska
- ☐ Illinois
- ☐ Nevada
- ☐ Indiana
- ☐ New Hampshire
- ☐ New Jersey
- ☐ South Dakota
- ☐ New Mexico
- ☐ Tennessee
- ☐ New York
- ☐ Texas
- ☐ North Carolina
- ☐ Utah
- ☐ North Dakota
- ☐ Vermont
- ☐ Ohio
- ☐ Virginia
- ☐ Oklahoma
- ☐ Washington
- ☐ Oregon
- ☐ West Virginia
- ☐ Pennsylvania
- ☐ Wisconsin
- ☐ Rhode Island
- ☐ Wyoming
- ☐ South Carolina

Below, you will be presented with a series of statements about the company's top management attitude towards health and safety. Please indicate your level of agreement or disagreement with the statements with respect to your experience with the company by checking (√) only one appropriate box. (1 = strongly disagree; 3 = neutral - neither disagree nor agree; 5 = strongly agree).

Top Management Safety Attitude Statement		Score				
		1 (disagree)	2	3	4	5 (agree)
I. Safety Policy						
1	The company has safety related criterion for subcontractor selection (e.g. past safety records).					
2	The company has safety related criterion for workers' recruitment (e.g. experience, safety training).					
3	The company has safety related criterion for managers' & supervisors' recruitment (e.g. experience, safety training).					
4	The revisions (where relevant) are promptly brought to the attention of all employees.					
5	The review arrangement includes feedback from employees at all levels.					
6	The safety policy clearly states that decisions on other priorities should give due regard to construction safety requirements.					
7	There are effective arrangements for reviewing the health and safety policy at least once a year.					
8	The company has a well-written substance abuse program.					
9	The company has a well-written light-duty, return-to-work policy.					
10	The policy endeavors to set targets (corporate safety goals) for health and safety performance including a commitment to progressive improvement.					

11	The policy identifies key senior personnel for overall coordination and implementation of the policy.					
12	The company has a well established disciplinary process for enforcement of safety program/safety plan.					
13	The company has a well-written safety field manual.					
14	As part of company policy, workers are given a booklet containing work rules, responsibilities, and other appropriate information.					
15	The company has a well-written personal protective equipment (PPE) policy.					
16	The policy is explained to new employees as part of their training and orientation before entry to a work on-site.					
17	The company has a well-written policy on accident reporting and investigation.					
18	The policy explicitly commits the organization to full compliance with all relevant health and safety legislation.					
19	The company has a well-written safety program manual/ safety plan.					
II. Management Commitment and Support						
20	The number of safety officers delegated on a site depends on the perceived/ evaluated hazards and complexity of the site.					
21	The management emphasizes on having project safety committees.					

22	Safety is a mandatory part of the supervisor's performance evaluation.					
23	There are effective arrangements to collect and review worker feedback on health and safety matters.					
24	The executive management reviews accident reports.					
25	The safety officers are delegated the responsibility and authority to suspend work if there are unsafe acts.					
26	The executive management involves itself in promoting safety by giving directions/ motivation.					
27	The executive management involves itself in enacting incentive schemes to encourage staff and subcontractors to observe safety					
28	The executive management involves itself in attending or chairing safety committees.					
29	The management clearly emphasizes safety over productivity.					
30	The number of safety officers delegated on a site depends on the accident records.					
31	The executive management reviews safety statistics.					
32	The number of safety officers delegated on a site depends on the requirements of the law/ the contract.					
33	The executive management reviews inspection reports.					
34	The executive management involves itself in requiring and facilitating regular safety					

	inspection on sites.					
35	The names and positions with responsibility lines for safety performance management are explicitly identified (such as an organization chart).					
36	The management sets corporate safety goals.					
37	The management always keeps someone in charge of updating health and safety including changes to regulations, new codes of practice, newly identified hazards, and new work practices.					
38	Management strongly emphasizes that safety problems be openly discussed between workers and supervisors.					
39	Management strongly emphasizes that workers be involved in site safety decisions.					
40	As per management directives, a formal behavior observation program exists on work sites.					
41	Management strongly encourages workers to raise safety concerns with their supervisors.					
42	Management emphasizes that workers be involved in preparation of site safety plans.					
43	Management strongly emphasizes that subcontractors/ subcontractor safety rep/ subcontractor staff be involved in site safety decisions.					
44	Management communicates lessons from accidents to workers in order to improve safety performance.					
45	As per management directives, site managers and supervisors are required to engage					

	themselves in regular safety talks with operatives.					
IV. Safety Training and Orientation						
46	The safety program requires subcontractors to hold regular safety meetings.					
47	The effectiveness of health and safety training is monitored by the company by checking new skills.					
48	Management strongly emphasizes on site managers and supervisors in meetings to maintain a positive attitude towards safety so that workers take safety on the site seriously.					
49	The safety program requires all subcontract workers to attend a formal standard safety orientation.					
50	The health and safety training program/ plan exists at the managerial level.					
51	The safety program requires holding tool box/ tailgate safety meetings focused on specific work operations/exposures.					
52	The safety program requires conducting safety inductions for site visitors.					
53	The health and safety training program/ plan exists at the supervisory level.					
54	Safety training is always a line or compulsory item within the budget.					
55	The health and safety training program/ plan exists at the workforce level.					
56	The safety program requires conducting site safety orientation for every person new to the					

	job site.					
57	The safety program requires safety training meetings for each supervisor (foreman and above).					
58	The company has a well-documented health and safety training program/ plan					
59	The safety program requires equipment operation/certification training.					
V. Safety Administration and Procedures						
60	The company has an established system to recognize safety accomplishments (such as award given out on a regular basis with recognition given for good safety performance.					
61	Any non-compliance to wearing appropriate PPE is required by the management to be investigated.					
62	Management motivates workers to work safely by providing incentives/ awards/ recognitions for good safety performance (e.g. monetary incentives).					
63	The work rules are regularly updated.					
64	There are appropriate arrangements to monitor the effectiveness and thoroughness of safety inspection.					
65	There are appropriate arrangements to collect and analyze the results of safety inspections.					
66	There are appropriate arrangements to ensure that action is taken as a result of the findings of safety inspections.					

67	The safety program requires having pre-task meetings before executing an activity.					
68	The safety program requires performing site layout planning before start of work.					
69	The management discusses safety at all preconstruction and progress meetings.					
70	The company's written safety program addresses safety communications procedures.					
71	The company's written safety program addresses safety risk identification and management procedures.					
72	The company's written safety program addresses safety planning procedures.					
73	Management disciplines workers to work safely by imposing disciplinary action (e.g. penalties) for safety non-performance.					
74	The safety program requires conducting emergency response drills.					
75	The company's written safety program addresses physical controls and rules.					
76	The company's written safety program addresses safety organization and responsibilities.					
77	The company's written safety program addresses safety implementation, monitoring and control procedures.					
78	The company's written safety program addresses safety training and awareness procedures.					
79	The company's written safety program addresses safe work procedures.					

80	Safety bulletin boards are provided and located so that every employee will see them during working days.					
81	The safety program requires maintaining a site hazard register containing hazards, impacts and preventive measures.					
82	The company's written safety program addresses safety reporting procedures.					
83	Safety signs and posters are prominently displayed on work sites.					
84	The company maintains jobsite safety checklists (or similar tools) for inspection.					
85	The company's written safety program addresses accident and emergency response mechanisms.					
86	The safety program requires conducting regular job site safety inspections/ audits.					
87	The company has documented safety work rules/ procedures for all site operations performed by the company (such as excavation works, trenching works, high rise work etc.).					
88	Site safety inspections are required to include routine safety inspection of equipment (e.g., scaffold, ladders, fire extinguishers, etc.).					
89	There are established procedures to ensure the proper use of PPE as well as its training and inspection.					
90	The company maintains PPE facilities on worksites.					
91	The company maintains continuous supply of					

	first aid facilities on work sites.					
VI. Accident Investigation and Reporting						
92	The company has a system to effectively use safety records and logs for enhancing safety performance.					
93	Management requires investigating near misses to help prevent accidents.					
94	Management requires reporting incidents/ near misses in the company's reporting system.					
95	After each accident, appropriate steps are taken to prevent similar accidents in future.					
96	The company always investigates accidents.					
97	Management requires keeping safety records and logs (such as in a database that logs injuries on past projects).					

Appendix B – Survey Instrument 2

Assessment of Current Safety Attitudes and Approaches of Supervisors and Foremen in the Construction Industry

(To be filled by Foremen and Supervisors)

All the information gathered here will be kept strictly confidential and will be used only for research and analysis without mentioning the person or company names. Thank you very much for your cooperation.

Personal Information (Optional)

Name of Respondent: ____

Present position in the company: ____________________________________

Total work experience: ____________ years

Work experience in this company: __________ years

Please provide contact info if you like to be contacted again regarding this questionnaire:

____

Company Information

Company Name: ____

Company Location (City & State): ____________________________________

Type of Company (Contractor Trade):

- ☐ General Contractor (GC)
- ☐ Poured Concrete Foundation and Structure Contractor
- ☐ Structural Steel and Precast Concrete Contractor
- ☐ Framing Contractor
- ☐ Masonry Contractor
- ☐ Glass and Glazing Contractor
- ☐ Roofing Contractor
- ☐ Siding Contractor
- ☐ Electrical Contractor
- ☐ Plumbing, Mechanical & HVAC Contractor
- ☐ Drywall and Insulation Contractor
- ☐ Painting and Wall Covering Contractor
- ☐ Flooring Contractor
- ☐ Tile and Terrazzo Contractor
- ☐ Finish Carpentry Contractor
- ☐ Site Preparation Contractor
- ☐ Other ___________________________

Approx. company size (no. of persons): ________ (admin) _______ (technical)

Number of Years in Business: ___________

Approx. annual turnover (in millions): ______________

States of operation (Check all that apply):

- ☐ Alabama
- ☐ Iowa
- ☐ Alaska
- ☐ Kansas
- ☐ Arizona
- ☐ Kentucky
- ☐ Arkansas
- ☐ Louisiana
- ☐ California
- ☐ Maine
- ☐ Colorado
- ☐ Maryland
- ☐ Connecticut
- ☐ Massachusetts
- ☐ Delaware
- ☐ Michigan
- ☐ District of Columbia
- ☐ Minnesota
- ☐ Florida
- ☐ Mississippi
- ☐ Georgia
- ☐ Missouri
- ☐ Hawaii
- ☐ Montana
- ☐ Idaho
- ☐ Nebraska
- ☐ Illinois
- ☐ Nevada
- ☐ Indiana
- ☐ New Hampshire
- ☐ New Jersey
- ☐ South Dakota
- ☐ New Mexico
- ☐ Tennessee
- ☐ New York
- ☐ Texas
- ☐ North Carolina
- ☐ Utah
- ☐ North Dakota
- ☐ Vermont
- ☐ Ohio
- ☐ Virginia
- ☐ Oklahoma
- ☐ Washington
- ☐ Oregon
- ☐ West Virginia
- ☐ Pennsylvania
- ☐ Wisconsin
- ☐ Rhode Island
- ☐ Wyoming
- ☐ South Carolina

Below, you will be presented with a series of statements about the responsibilities of a foreman or a supervisor towards health and safety on a construction site. Please indicate your level of agreement or disagreement with the statements with respect to your experience with the company by checking (√) only one appropriate box. (1 = strongly disagree; 3 = neutral - neither disagree nor agree; 5 = strongly agree).

Supervisor Safety Responsibility Statement		**Score**				
		1 (disagree)	2	3	4	5 (agree)
I. Safety Training and Orientation						
1	I am responsible to provide job-specific safety training					
2	I am responsible to hold tool box/ tailgate safety meetings focused on specific work					

	operations/exposures					
3	I am responsible to hold safety meetings					
4	I am responsible to coach workers					
5	I am responsible to explain safety operations/ rules to workers					
6	I am responsible to orient new workers					
II. Safety Administration						
7	I am responsible to establish inspection teams for hazard analysis					
8	I am responsible to investigate accidents					
9	I am responsible to correct unsafe conditions					
10	I am responsible to take unsafe tools out of production					
11	I am responsible to correct unsafe acts					
12	I am responsible to report all incidents/ near misses					
13	I am responsible to authorize regular maintenance or repair of equipment					
14	I am responsible to report all accidents					
15	I am responsible to maintain first aid facilities					
16	I am responsible to conduct (safety) inspection of my own division of work					
17	I am responsible to send the injured or sick workers for medical attention					
III. Maintaining Discipline						

18	I am responsible to require workers to report any malpractice by a fellow worker					
19	I am responsible to conduct emergency response drills					
c20	I am responsible to report a worker for unsafe acts					
21	I am responsible to discharge a worker's duties					
22	I am responsible to recommend promotion or demotion to a worker					
23	I am responsible to issue warnings to workers in case of unsafe acts					
24	I am responsible to enforce the use of personal protective equipment whenever necessary					
IV. Safety Communication						
25	I am responsible to recommend changes in safety policy					
26	I involve/ consult workers in preparation of task safety plan					
27	I encourage feedback from workers on safety issues					
28	I am responsible to improve safe work procedures through worker involvement					
29	I keep an open-door policy on safety issues					
30	I take responsibility to communicate workers' safety concerns to management					
31	I take responsibility to make suggestions to					

	improve safety					
32	I take responsibility to discuss safety problems with the management					
V. Safety Commitment and Support						
33	I emphasize on workers to contribute to job safety analysis					
34	I ensure good preparedness for emergency among workers					
35	I allow workers to act decisively if they find any situation contrary to safe conditions on site					
36	I participate actively in developing / reviewing health and safety procedures					
37	I take responsibility to ensure that the workload is reasonably balanced among workers					
38	I emphasize on workers to contribute to accident investigations					
39	I continuously emphasize on workers that safety rules should not be broken, even when worker believes it affects the production					
40	I emphasize on a no-blame approach to highlight unsafe work behavior					
41	I emphasize on workers to achieve high levels of safety performance					
42	I take responsibility to provide right equipment to the workers so that they can do the job safely					
43	I take responsibility to detect potential					

	hazards as part of the planning exercise					
44	I often remind workers to work safely					
45	I emphasize on workers that everyone has the responsibility to reflect on safety practice					
46	I emphasize on workers that safety is the number one priority while working					
47	I keep safety as a primary consideration when planning					
48	I take responsibility to never allow working with defective equipment					
49	I emphasize on workers to report accidents, incidents, and potentially hazardous situations					
50	I emphasize on workers to offer help to fellow workers when needed to perform the job safely					
51	I emphasize on workers to maintain a good relationship with fellow workers					
52	I emphasize on workers to play an active role in identifying site hazards					
53	I endeavor to maintain a positive attitude towards safety during meetings so that workers take safety on the site seriously					
54	I take responsibility to identify potential risks & consequences prior to execution					
55	I emphasize on workers to ensure that individuals are not working by themselves under risky or hazardous conditions					
56	I react strongly against workers who break health and safety procedures / instructions / rules.					

VI. Maintaining a Positive Attitude						
57	I engage myself in regular safety talks (discuss safety problems openly with workers and supervisors)					
58	I never advocate working around safety procedures to meet deadlines					
59	I welcome reporting safety hazards/incidents					
60	I gather ideas from workers about improving safety when significant changes to work practices are suggested					
61	I provide the help, authority, information & resources workers need to behave safely					
62	I always inform workers of safety concerns and issues.					
63	I take responsibility to solve safety problems					
VII. Motivating						
64	I take responsibility for assuring job security of workers under my belt					
65	I am responsible for recommending recognition/ reward for good safety performance					
66	I take responsibility for helping and caring for workers' personal problems					
67	I take responsibility for creating feeling of belonging among workers					
68	I take responsibility for promoting job satisfaction among workers					

Appendix C– Survey Instrument 3

Assessing the Criticism on the Role of OSHA as a Driving Force towards implementing a Total Safety Culture in a Construction Organization

(To be filled by Contractor Top Management incl. CEO, Operations Head, Construction Head, Safety Department Head, Project Management Division Head, etc.)

Personal Information (Optional)

Name of Respondent: ____

Present position in the company: _________________________________

Total work experience: ______________ years

Work experience in this company: ___________ years

Please provide contact info if you like to be contacted again regarding this questionnaire:

____

Company Information

Company Name: ____

Company Location (City & State): ________________________________

Type of Company (Contractor Trade):

- ☐ General Contractor (GC)
- ☐ Poured Concrete Foundation and Structure Contractor
- ☐ Structural Steel and Precast Concrete Contractor
- ☐ Framing Contractor
- ☐ Masonry Contractor
- ☐ Glass and Glazing Contractor
- ☐ Roofing Contractor
- ☐ Siding Contractor
- ☐ Electrical Contractor
- ☐ Plumbing, Mechanical & HVAC Contractor
- ☐ Drywall and Insulation Contractor
- ☐ Painting and Wall Covering Contractor
- ☐ Flooring Contractor
- ☐ Tile and Terrazzo Contractor
- ☐ Finish Carpentry Contractor
- ☐ Site Preparation Contractor
- ☐ Other ____________________________

Approx. company size (no. of persons): _________ (admin) ________ (technical)

Number of Years in Business: ___________

Approx. annual turnover (in millions): ______________

States of operation (Check all that apply):

- ☐ Alabama
- ☐ Iowa
- ☐ Alaska
- ☐ Kansas
- ☐ Arizona
- ☐ Kentucky
- ☐ Arkansas
- ☐ Louisiana
- ☐ California
- ☐ Maine
- ☐ Colorado
- ☐ Maryland
- ☐ Connecticut
- ☐ Massachusetts
- ☐ Delaware
- ☐ Michigan
- ☐ District of Columbia
- ☐ Minnesota
- ☐ Florida
- ☐ Mississippi
- ☐ Georgia
- ☐ Missouri
- ☐ Hawaii
- ☐ Montana
- ☐ Idaho
- ☐ Nebraska
- ☐ Illinois
- ☐ Nevada
- ☐ Indiana
- ☐ New Hampshire
- ☐ New Jersey
- ☐ South Dakota
- ☐ New Mexico
- ☐ Tennessee
- ☐ New York
- ☐ Texas
- ☐ North Carolina
- ☐ Utah
- ☐ North Dakota
- ☐ Vermont
- ☐ Ohio
- ☐ Virginia
- ☐ Oklahoma
- ☐ Washington
- ☐ Oregon
- ☐ West Virginia
- ☐ Pennsylvania
- ☐ Wisconsin
- ☐ Rhode Island
- ☐ Wyoming
- ☐ South Carolina

Based on your experience and judgment, please select your level of agreement with each of the following negative statements about OSHA. Please indicate your level of agreement or disagreement with the statements with respect to your experience/ expert judgment by checking (√) only one appropriate box. (1 = strongly disagree; 3 = neutral - neither disagree nor agree; 5 = strongly agree).

Note that "Strongly Agree" (5) means you strongly agree to the negative statement (i.e. OSHA is doing very bad on the aspect under question), while "Strongly Disagree" (1) means you strongly disagree to the negative statement (i.e. OSHA is doing very good on the aspect under question).

OSHA Performance Statement		Score				
		1 (disagree)	2	3	4	5 (agree)
I. Regulations and Standards						
1	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker productivity.					
2	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that has a negative impact on worker acceptance to safety policies and procedures.					
3	OSHA takes extraneous amount of time to actualize new regulations/ standards.					
4	Existing OSHA procedures are not updated timely.					
5	OSHA health and safety procedures/ instructions/ rules are not generally practicable (implementable).					
6	OSHA health and safety procedures/ instructions/ rules generally fail to reflect how the job is actually done.					
7	OSHA'S overloaded guidelines deliver an overbearing and unwanted presence that greatly restricts an organization's ability to develop as well as compete					
8	OSHA regulations and standards fail to incorporate current technology.					
9	OSHA regulations/ procedures can be easily manipulated by some companies.					
10	OSHA regulations/ standards/ procedures are generally burdensome (trying to do too much					

	without any practical advantage).					
11	OSHA regulations are generally over-strict.					
12	OSHA regulations/ standards/ procedures are generally confusing (not very clear to implement).					
13	Substantial amount of capital has been needlessly wasted by your organization for complying with OSHA standards.					
14	Substantial amount of working hours have been needlessly lost by your organization for complying with OSHA standards.					
15	The cost of implementing OSHA regulations is usually unjustified as against their benefit in achieving reduced worker injury.					
II. Enforcement Methods						
16	The priority of OSHA inspections is mostly centered towards imposing penalties, rather than preventing accidents and/ or identifying problems.					
17	OSHA fails to provide adequate reward mechanisms.					
18	OSHA performs inadequate number of inspections.					
19	OSHA generally seems more interested in issuing the fine rather than correcting the problem.					
20	OSHA's methods are mostly directed towards correcting only single events, such as the one your company was fined for.					

21	The penalties/ fines imposed by OSHA are not usually justified in proportion to the violation.					
22	OSHA inspections are unbalanced distributed among construction firms.					
23	OSHA inspections are unbalanced distributed among different types of construction expertise.					
24	OSHA training programs are generally ineffective.					
25	OSHA inspection procedures are generally ineffective.					
26	OSHA is an overbearing bureaucracy with methods bearing little or no sensitivity to the needs & limitations of employers who are struggling to survive in a competitive marketplace.					
27	OSHA's heavy fines restrict an organization's ability to develop as well as compete.					
28	OSHA follow-up inspections (after initial citations have been issued) are usually performed at an unreasonably slower rate.					
29	OSHA deals with workplace accidents usually at an unreasonably slow rate.					
III. Vision and Approach						
30	OSHA has generally failed to take a proactive approach in developing long term safety measures.					
31	OSHA standards are mostly ineffective in setting up a Total Safety Culture on a construction jobsite (OSHA is the driving					

	force to implement a total safety culture in a construction organization).					
32	OSHA has not been concentrating enough on positive safety reinforcement.					
33	The expenditures made for compliance with OSHA regulations and/ or paying for fines could be spent in a more strategic way that would create a safer work environment and a better understating of safety.					
34	OSHA does not focus on the strategic picture by taking into consideration the underlying factors leading to accident (such as leadership, work pressure, communication) but rather focuses on the apparent causes of accident (such as lack of PPE).					
35	OSHA emphasizes more on appointing supervisors to administer fines in the workplace, rather than appointing personnel to act as health and safety advisors.					
36	OSHA, as a safety organization, is not actively participating in necessary research activities to view and incorporate safety as an industrial development process, which would have improved ways construction organizations can incorporate safety in the industry.					
37	OSHA representatives do not usually provide follow up information pertaining to the incident such as: how the accident could be corrected or any appropriate training that could be utilized to ensure the incident is not repeated.					
38	OSHA should train their inspectors better regarding on how to facilitate developing a strategic safety culture in a construction					

	organization leading to total safety.					
39	OSHA representatives do not usually provide information about how to improve safety strategically in your organization.					
40	OSHA is more devoted to inspections (monitoring) than to safety as a strategic concern.					
41	OSHA's safety approach restricts your organization by compelling it to increase investment in following procedures rather than investing in long-term safety objectives.					
42	OSHA focuses more on the employer actions rather than on the employee safety, thereby increasing the short term expenses of the organization instead of the long term investment.					
43	OSHA places a heavy burden on organizations by forcing increased operational fees and the costs associated to retrofit outdated equipment rather than investing on improving the processes for achieving long-term (strategic) safety objectives.					
44	OSHA's inspection and penalty approach of enforcement is an inappropriate and ineffective way to ensure workplace safety in the long-term.					

Appendix D Survey Instrument 4

Assessing the State of Adoption and Implementation of Total Safety Management in Construction Industry & Assessing the Readiness of Construction Contractors towards Implementing Total Safety Management

(To be filled by Contractor Top Management and Middle Management)

All the information gathered here will be kept strictly confidential and will be used only for research and analysis without mentioning the person or company names. Thank you very much for your cooperation.

Personal Information (Optional)

Name of Respondent: ____

Present position in the company: ____

Total work experience: _____________ years

Work experience in this company: ___________ years

Please provide contact info if you like to be contacted again regarding this questionnaire:

____

Company Information

Company Name: ____

Company Location (City & State): _____________________________________

Type of Company (Contractor Trade):

- ☐ General Contractor (GC)
- ☐ Poured Concrete Foundation and Structure Contractor
- ☐ Structural Steel and Precast Concrete Contractor
- ☐ Framing Contractor
- ☐ Masonry Contractor
- ☐ Glass and Glazing Contractor
- ☐ Roofing Contractor
- ☐ Siding Contractor
- ☐ Electrical Contractor
- ☐ Plumbing, Mechanical & HVAC Contractor
- ☐ Drywall and Insulation Contractor
- ☐ Painting and Wall Covering Contractor
- ☐ Flooring Contractor
- ☐ Tile and Terrazzo Contractor

☐ Finish Carpentry Contractor
☐ Site Preparation Contractor
☐ Other ____________________________

Approx. company size (no. of persons): _________ (admin) ________ (technical)

Number of Years in Business: ___________

Approx. annual turnover (in millions): ______________

States of operation (Check all that apply):

☐ Alabama
☐ Iowa
☐ Alaska
☐ Kansas
☐ Arizona
☐ Kentucky
☐ Arkansas
☐ Louisiana
☐ California
☐ Maine
☐ Colorado
☐ Maryland
☐ Connecticut
☐ Massachusetts
☐ Delaware
☐ Michigan
☐ District of Columbia
☐ Minnesota
☐ Florida
☐ Mississippi
☐ Georgia
☐ Missouri
☐ Hawaii
☐ Montana
☐ Idaho
☐ Nebraska
☐ Illinois
☐ Nevada
☐ Indiana
☐ New Hampshire
☐ New Jersey
☐ South Dakota
☐ New Mexico
☐ Tennessee
☐ New York
☐ Texas
☐ North Carolina
☐ Utah
☐ North Dakota
☐ Vermont
☐ Ohio
☐ Virginia
☐ Oklahoma
☐ Washington
☐ Oregon
☐ West Virginia
☐ Pennsylvania
☐ Wisconsin
☐ Rhode Island
☐ Wyoming
☐ South Carolina

Below, you will be presented with a series of statements about the state of adoption and implementation of total safety management in your company and the readiness of your company towards embracing total safety management. Please indicate your level of agreement or disagreement with the statements with respect to your experience with the company by checking (√) only one appropriate box. (1 = strongly disagree; 3 = neutral - neither disagree nor agree; 5 = strongly agree).

TSM Statement		Score				
		1 (disagree)	2	3	4	5 (agree)
I. Knowledge of TSM						
1	TSM can be achieved by measuring and keeping records of the number of accidents and incidents and applying punitive measures to workers that are caught violating safety rules.					
2	I am aware of construction industry programs implementing TSM.					
3	TSM programs should be based on scientific decision making.					
4	TSM can be achieved by making and maintaining a safe and healthy workplace as part of the company's strategic plan.					
5	TSM can be achieved by ensuring safe working through positive reinforcement and advice and improving by adopting good practice that exceeds legislative requirements.					
6	TSM programs should be strategically focused.					
7	TSM can be achieved by motivating staff through a measurement and reward scheme and providing the skills and information to enable staff to work safely via training and its intranet.					
8	TSM programs should focus on peak performance.					
9	TSM programs should have unity of purpose.					
10	TSM programs should be committed to					

	employee empowerment.					
11	TSM programs should be committed to continual improvement.					
12	TSM programs should be performance and process oriented.					
13	TSM programs are largely dependent on executive-level commitment.					
14	TSM programs should contain comprehensive, ongoing training.					
15	TSM programs should be teamwork oriented.					
II. Strategic Vision of Safety						
16	My company views safety as a tool to increase profits.					
17	My company views safety as a competitive advantage.					
18	My company's safety policy can be best defined as "Implementation of a set of safety rules by the Company with punitive measure for violators."					
19	My company's safety policy can be best defined as "a set of processes developed to manage safety aspects of a project including encouraging, measuring and rewarding behavior that creates a safe working environment rather than catching people who break the rules."					
20	My company's safety policy can be best defined as "a performance-and-process-control oriented approach to safety and health management that gives organization sustainable competitive advantage in the					

	marketplace by establishing a safe and healthy work environment that is conducive to consistent peak performance and that is improved continually."					
21	Poor safety performance decreases productivity and organizational performance.					
22	The company management strongly believes that excellence in safety would positively affect the ability to achieve excellence in other areas; e.g. production, etc.					
23	My company views safety and health as an integral part of its business.					
24	My company believes that poor safety performance restricts strategic organizational growth.					
25	OSHA regulations provide a driving force to implementing TSM.					
26	My company views safety as achieving zero accidents.					
27	My company views safety as elimination of hazards.					
28	A TSM program is (will be) beneficial for my organization.					
III. Strategic Approach to Safety Improvement						
29	Steps taken in implementing my organization's safety improvement program include: "A dollar value has been assigned to the cost of unsafe behaviors".					
30	"Obtaining client satisfaction" is a major objective of my organization's safety					

	improvement program.					
31	Training currently emphasizes: data gathering & analysis.					
32	"Pressure from competitors" was a key factor that provided the motivation to start the safety improvement program.					
33	Steps taken in implementing my organization's safety improvement program include: "Benchmarks for improvement have been defined".					
34	"Environmental issues/considerations" was a key factor that provided the motivation to start the safety improvement program.					
35	"Increasing productivity" is a major objective of my organization's safety improvement program.					
36	Steps taken in implementing my organization's safety improvement program include: "Organizing a multi-disciplinary team".					
37	Company's safety training is oriented towards TSM (or continuous safety improvement).					
38	The company's safety improvement program is centered on Total Safety Management and/ or zero accident strategies.					
39	"Safety of processes" was a key factor that provided the motivation to start the safety improvement program.					
40	Training currently emphasizes: process improvement.					
41	Steps taken in implementing my organization's safety improvement program					

	include: “Data has been collected to measure the safety performance”.					
42	“Demanding customers” was a key factor that provided the motivation to start the safety improvement program.					
43	“Need to reduce costs and improve performance” was a key factor that provided the motivation to start the safety improvement program.					
44	Steps taken in implementing my organization’s safety improvement program include: “An educational program has been implemented”.					
45	“My company’s chief executive” was a key factor that provided the motivation to start the safety improvement program.					
46	Steps taken in implementing my organization’s safety improvement program include: “Safety problems have been identified”.					
47	Training currently emphasizes: teamwork.					
48	Training currently emphasizes: communication.					
49	“Achieving zero accidents” was a key factor that provided the motivation to start the safety improvement program.					
50	“Ensuring involvement of employees in the safety building effort” is a major objective of my organization’s safety improvement program.					
51	Steps taken in implementing my organization’s safety improvement program include: “An internal awareness program is					

	underway".					
52	Training currently emphasizes: zero accident strategies.					
53	Formal training in TSM or other safety improvement philosophies is given to employees.					
54	After the implementation of my safety improvement program, the relationship with my customers and suppliers has improved.					
55	My organization's safety improvement program can be described as formal with widespread employee awareness.					
56	As part of the management team, we have a TSM Steering Committee/ a TSM Facilitator/ a safety improvement project team.					
57	The company provides feedback loops to determine if the safety improvement practices are working.					
58	After the implementation of my safety improvement program, worker behaviors have improved.					
59	"Employee safety" was a key factor that provided the motivation to start the safety improvement program.					
60	"Health and Safety agencies (like OSHA)" was a key factor that provided the motivation to start the safety improvement program.					
IV. Employee Involvement and Empowerment						
61	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous					

	safety improvement) include: serving effectively on improvement teams".					
62	There is an anonymous way for employees to make safety improvement suggestions. e.g. drop box.					
63	The company has a mentoring program for all new employees to develop safe working habits.					
64	The company has incentive programs to reward workers, supervisors, superintendents, or specific teams for outstanding safety performance and/or for generating ideas to reduce the number of accidents.					
65	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "practicing hazard identification techniques constantly".					
66	The level of feedback collected from employees is very significant for setting safety goals.					
67	The level of feedback collected from employees is very significant for selecting safe projects.					
68	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "encouraging fellow employees to work safely".					
69	The extent to which the employees provide input that is useful in making continual safety improvements to the organization is very significant.					

70	The level of feedback collected from employees is very significant for measuring safety improvement.					
71	The level of feedback collected from employees is very significant for identifying solutions.					
72	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "setting positive examples of working safely".					
73	Methods adopted in the company to encourage employees to fulfill their responsibilities towards TSM (or continuous safety improvement) include: "recommending accident prevention strategies".					
74	Employee feedback is almost always included in the safety decision making process.					
75	Employees are empowered to make significant safety improvement suggestions and changes to operations.					
76	The level of feedback collected from employees is very significant for identifying safety issues.					
77	The importance of employee input in my company's safety improvement program is very high.					
V. Readiness to Embrace TSM						
78	All team members understand how unsafe team members will be guided for improvement.					

79	Decisions are supported by all in my organization.					
80	All team members understand how team decisions are made.					
81	“Company executives/ managing directors” are involved in safety management efforts/ activities.					
82	“Appropriate storage practices” are my company’s strength in terms of safety.					
83	Company looks at the past safety performance (safety portfolio) of a prospective employee as an important criterion for selection.					
84	“Consistent commitment to improvement” promotes safety conscience in my company.					
85	The organization has a mission statement with specific responsibilities for approval of recommendations for improvement of the work environment.					
86	My company provides (or strives to provide): safety information.					
87	In my company, we would never compromise safety to meet deadlines.					
88	“Employee participation” promotes safety conscience in my company.					
89	The organization has a mission statement with specific responsibilities for building safety and health concerns into the strategic plan.					
90	The responsibility of the accidents and their effects belongs to the whole organization.					
91	“Management leadership” promotes safety conscience in my company.					

92	Team's success is understood by all team members in my organization.					
93	Team's goal is understood by all team members in my organization.					
94	"An active TSM steering committee/ safety improvement team" is my company's strength in terms of safety.					
95	All team members understand their authority within the team and that of all other team members.					
96	All team members know the responsibilities of all other team members.					
97	"A capable and committed safety director" is my company's strength in terms of safety.					
98	When unforeseen inhibitors impede progress all members know what to do.					
99	The whole organization is responsible to follow and get involved in the safety & health mission accomplishment.					
100	My company provides (or strives to provide): management encouragement towards safety.					
101	Company uses the method of positive reinforcement for good safety practices.					
102	Safety practices are recognized and rewarded.					
103	The whole organization is responsible to assess the safety precautions and rules.					
104	Company follows independent (cold eye) safety reviews and ratings.					
105	My company provides (or strives to provide): safe working environment.					

106	"Company administration and support" are involved in safety management efforts/ activities.					
107	"Self accountability" promotes safety conscience in my company.					
108	My company provides (or strives to provide): clearly defined mission statement.					
109	"Commitment by senior management" is my company's strength in terms of safety.					
110	"Individual employees" are involved in safety management efforts/ activities.					
111	Peer pressure exists among workers to work in a safe and healthy manner.					
112	Everyone is open and honest with each other in my organization.					
113	Safety mission is understood by all team members in my organization.					
114	Company looks at past safety performance of the subcontractors/ suppliers as an important criterion for selection.					
115	The organization has a mission statement with specific responsibilities for regular review of the safety and health program in order to keep up with the safety best practices.					
116	"A comprehensive safety and health plan" is my company's strength in terms of safety.					
117	My company provides (or strives to provide): safety manager or safety committee.					
118	"Safe facilities" are my company's strength in terms of safety.					

119	"Up-to-date safety procedures" is my company's strength in terms of safety.					
120	My company provides (or strives to provide): formal, written statement of corporate safety policies and objectives.					
121	"Safe equipment" is my company's strength in terms of safety.					
122	"Project managers" are involved in safety management efforts/ activities.					
123	"Site managers" are involved in safety management efforts/ activities.					
124	My company provides (or strives to provide): personal protective equipment.					
TSM Benefits		**Score**				
		1 (disagree)	2	3	4	5 (agree)
125	TSM improves performance.					
126	TSM increases employee morale.					
127	TSM increases profits.					
128	TSM provides the opportunity to avoid costly redesign or project delay by addressing hazard issues as early as possible.					
129	TSM provides traceable and effective hazard management system.					
130	TSM provides a check-and-balance mechanism at different stages of a project lifecycle.					

TSM Obstacles		**Score**				
		1 (disagree)	2	3	4	5 (agree)
131	"Changing attitudes and behaviors" is an obstacle in TSM implementation.					
132	"Emphasis on short-term objects" is an obstacle in TSM implementation.					
133	"Lack of top-management commitment/ understanding" is an obstacle in TSM implementation.					
134	"Lack of education and training to drive the improvement process" is an obstacle in TSM implementation.					
135	"Schedule and cost treated as the main priorities" is an obstacle in TSM implementation.					
136	"Current bidding climate" is an obstacle in TSM implementation.					
137	"Lack of employee commitment/ understanding" is an obstacle in TSM implementation.					
138	"Lack of expertise/resources in TSM" is an obstacle in TSM implementation.					
139	"Tendency to cure symptom rather than eradicate the root cause" is an obstacle in TSM implementation.					

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VITA

RIZWAN UL-HAQUE FAROOQUI

Education

- Ph.D. student (2006-2011) in Civil Engineering majoring in Construction Engineering & Management, Florida International University, Miami, Florida, USA. Dissertation Topic: Achieving Zero Accidents – A Strategic Framework for Continuous Safety Improvement in the Construction Industry.
- MS (2001) in Civil Engineering majoring in Structural and Construction Engineering, National University of Singapore, Singapore.
- BE (1998) in Civil Engineering, NED University of Engineering and Technology, Karachi, Pakistan.

Appointments

- Aug 2006 – Apr 2011, Ph.D. Student, Research and Teaching Assistant, Adjunct Faculty, Florida International University, Miami, FL, USA
- Mar 2004 – July 2006, Project Management Consultant (part-time), TEAMS, Karachi, Pakistan
- Jan 2002 – Present, Assistant Professor, Department of Civil Engineering, NED University of Engineering and Technology, Karachi, Pakistan
- Jan 2000 – Mar 2001, MS Student, National University of Singapore, Singapore
- Jan 1999 – Dec 1999, Design Engineer, AA Associates, Karachi, Pakistan

Statistics of Research Grants, Publications and Scholarly Activities

Funded Research (Completed)	1 (USD 403,000)
Refereed Journal Papers	10
Refereed Proceedings Papers	71
Edited Proceedings	2
Books (co-authored)	1
Book Chapters, Excerpts and Articles	3
Technical Reports	1
Member review panel on peer reviewed journals	2
Member review panel on peer reviewed conferences	6
Member organizing committee on peer reviewed conferences	2

Summary of Awards and Scholarships

Competitive study grant	USD 100,000
Ph.D. Fellowship	USD 25,000
Scholarships	USD 5,750
Best scholarly paper awards (conferences)	6 nos.
Best scholarly paper awards (scholarly forums)	4 nos.

Statistics of Teaching, Training and Research Supervision Activities

Graduate Courses (face-to-face)	14
Graduate Courses (online)	7
Undergraduate Courses	7
Total Teaching hours (undergraduate & graduate)	5052
Corporate training hours	>400
Supervision of master's thesis	3
Supervision of master's level independent studies	12
Supervision of undergraduate projects	16

- Developed the master's program in engineering management with specializations in construction management and industrial management at NED University of Engineering & Technology, Karachi, Pakistan.
- Developed a proposal for the master's program in construction management at University of Engineering & Technology, Texila, Pakistan.
- Developed 28 graduate courses and 3 undergraduate courses
- Expanded, revised and updated almost all the undergraduate and graduate courses taught during the past nine years

Summary of Professional, Honorary and Community Memberships

Member professional organizations	6 nos.
Member honor associations	6 nos.
Member community service organizations	3 nos.

Selected Consultancy

- Project management for construction of STIEFEL laboratories production plant in Lahore, Pakistan, 2007-2008
- Construction process re-engineering (CPR) for SUR construction (PLC.) Ethiopia, 2004-2006
- Production planning and resource optimization for Dollar industries, Pakistan, 2004
- Implementation of a project management information system (PMIS) for Alstom Pakistan, 2003
- Portfolio management at project management office for Techno Consult International, Pakistan, 2003
- Project management of 2nd 100 MGD K-III project for Techno Consult International, Pakistan, 2003
- Project management of RBOD extension from Sehwan to sea for Mott Mcdonalds Pakistan (MMP), 2003