



**AN ANALYSIS OF THE CAUSES OF CONSTRUCTION  
ACCIDENTS IN SOUTH AFRICA: A CASE STUDY APPROACH**

**BY**

**TRINISHA LUTCHMIAH**

**A DISSERTATION SUBMITTED TO THE HIGHER DEGREES COMMITTEE OF THE  
UNIVERSITY OF KWAZULU-NATAL IN FULFILLMENT OF THE REQUIREMENTS FOR  
THE DEGREE MASTER OF SCIENCE: CONSTRUCTION MANAGEMENT**

**UNIVERSITY OF KWAZULU-NATAL  
SOUTH AFRICA**

**Supervisor: Theo C. Haupt, Ph.D., M.Phil., Pr. CM**

**2018**

## PREFACE

The research contained in this dissertation was completed by the candidate while based in the Discipline of Construction Studies, School of Engineering of the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Howard, South Africa.

The contents of this work have not been submitted in any form to another university and, except where the work of others is acknowledged in the text, the results reported are due to investigations by the candidate.

A handwritten signature in black ink, appearing to read 'T. C Haupt', is written over a horizontal line.

Signed: T. C Haupt (Supervisor)

Date: October 2018

## DECLARATION 1: PLAGIARISM

I, Trinisha Lutchmiah, declare that:

(i) the research reported in this dissertation, except where otherwise indicated or acknowledged, is my original work;

(ii) this dissertation has not been submitted in full or in part for any degree or examination to any other university;

(iii) this dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;

(iv) this dissertation does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

a) their words have been re-written but the general information attributed to them has been referenced;

b) where their exact words have been used, their writing has been placed inside quotation marks, and referenced;

(v) where I have used material for which publications followed, I have indicated in detail my role in the work;

(vi) this dissertation is primarily a collection of material, prepared by myself, published as journal articles or presented as a poster and oral presentations at conferences. In some cases, additional material has been included;

(vii) this dissertation does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the dissertation and in the References sections.



---

Signed: Trinisha Lutchmiah

Date: October 2018

## ABSTRACT

It is well-known that construction represents a challenging regime in which to manage health and safety exacerbated by the enormous diversity in terms of the size and range of its activities (HSE, 2001). Health and safety improvements in the workplace are developed and shaped because of the knowledge gained and assumptions made from accidents that have occurred (Gibb, Lingard, Behm and Cooke, 2014). Understanding what causes accidents is important as it helps distinguish between factors that require attention and remedial action and factors that are unimportant and can be ignored (Swuste, 2008). There are several theories that exist created by scholars in attempts to provide understanding of the causation of accidents on construction sites. Some of these theories are discussed in this study, namely:

- Accident Proneness Theory;
- Goals-Freedom-Alertness Theory;
- Adjustment-Stress Theory;
- Distractions Theory;
- Chain of events (Domino and Updated Domino theory);
- Multiple Causation Model;
- Reason's Framework for Accident Causation;
- Constraint-Response Theory;
- Human Error Theories; and
- Systemic accident model

Despite these theories, accidents have continued unabated. Typically, these theories have focused on the construction worker as being the primary cause of accidents – a basic tenet of the behavioural safety approach espoused by Krause and Hidley (1990) and others. According to Whittington et al. (1992), emphasis on individual failures resulted in a reliance on short-term solutions rather than uncovering more fundamental management or organisational problems. Generally, the proposed remedy targeted a specific event or operative, such that no effort was made to uncover the underlying cause of the accident. The HSE (2001) observed that changes at the direct level alone would not deliver the degree of change being sought, nor would the resultant improvement be sustained.

This study utilised a qualitative research approach and a combination of descriptive and analytical research methods namely both questionnaires and case studies to analyse the problem statement. The sample design used in this study is based on quota sampling as a sample of any 30 lost time accidents investigation reports were required from the large participating construction company for selection and analysis for this study. A further sample of 10 Contractors and Health and Safety Officers were surveyed to test if the findings of the case study were in line with what these professionals actually experience on site.

A sample of 30 accident investigation reports were analysed by categorising every cause identified in these reports according to the relevant accident causation theories to determine which theories most prevalently or most frequently would have identified the causes as shown in the construction company's accident investigation reports. The frequency of each accident causation theory was analysed to determine if the identified causes of the accidents were focused on the actions and failures of workers or management and if the remedial actions taken were correct and were able to prevent the accident from reoccurring according to the theories they were classified under. The causes of the 30 construction accidents as stated in the respective accident investigation reports were classified into three categories namely: *Direct Causes*, *Contributory Causes* and *Root Causes* to determine if the root causes were in fact identified

The findings of the case study indicated that the construction accident investigation reports are flawed as they typically fault the negligence of workers as being the root cause of construction accidents. The majority of the construction professionals surveyed were of the opinion that accident investigation, although effective, can be improved. However, the case study findings indicate that accident investigation processes and methods are ineffective as 83% of accident investigation reports incorrectly identified direct and contributory causes which the suggested remedial action was not based on root causes.

## ACKNOWLEDGMENTS

I would like to acknowledge and thank the following important people who have supported me throughout my masters degree.

Firstly, I would like to express my sincerest gratitude to Professor Theodore Haupt from the University of KwaZulu Natal for pushing me to complete my masters degree and for the tremendous advice and supervision.

Mike Edwards, my mentor and manager at Engen Petroleum for the constant support, encouragement and time off whenever I needed it to get this dissertation done. You made the juggle of working and completing my dissertation much easier.

A big thank you to Joseph Khoza, without whom I would have not completed this study. Thank you for always being willing to help.

I would like to thank and acknowledge my family, my mother – Yana, my father – Devan, my sisters, Kerisha and Levanya and my cousin Deeandra for being a source of inspiration and motivation. You have all played such a major role in moulding me into the person I am today, and I will forever be grateful for your love and invaluable lessons.

Finally, to my partner Keenen, for always believing in me and making me believe I could do anything I put my mind to. Thank you for your unwavering love, motivation and insight. You have really helped me focus on what has been a truly rewarding and enriching process.

## TABLE OF CONTENTS

PREFACE .....	ii
DECLARATION 1: PLAGIARISM .....	iii
ABSTRACT .....	iv
ACKNOWLEDGMENTS .....	vi
TABLE OF CONTENTS .....	vii
LIST OF TABLES .....	x
LIST OF FIGURES .....	xi
Definition of Key Terms and Concepts.....	1
CHAPTER 1: INTRODUCTION .....	2
1.1    Introduction .....	2
1.2    Background .....	2
1.3    Accident causation theories.....	4
1.4    Problem Statement .....	4
1.5    Research Hypotheses.....	5
1.6    Research Objectives .....	5
1.7    Research Methodology.....	6
1.8    Limitations of the study.....	7
1.9    Delimitations of the study .....	7
1.10   Assumptions.....	7
1.11   Ethical Considerations.....	7
1.12   Structure of Study.....	8
1.13   Summary .....	9
CHAPTER 2: LITERATURE REVIEW .....	10
2.1    Introduction .....	10
2.2    Nature of the industry.....	10
2.3    “Accident” versus “Incident” .....	11
2.4    Accident causation theories.....	12
2.4.1  Accident Proneness Theory.....	15
2.4.2  Goals-Freedom-Alertness Theory .....	16
2.4.3  Adjustment-Stress Theory.....	17
2.4.4  Distractions Theory .....	18

2.4.5	Chain of events (Domino theory).....	19
2.4.6	Multiple Causation Model.....	25
2.4.7	Reason’s Epidemiological Model .....	26
2.4.8	Constraint-Response Theory .....	28
2.4.9	Human Error Theories.....	30
2.4.10	Systemic accident models .....	30
2.4.11	Hierarchy of Causal Influences in Construction Accidents Model.....	35
2.5	Analysis of Construction Accidents .....	39
2.6	The Accident Model.....	40
2.7	Other causation models .....	42
2.8	Accident investigation methods .....	43
2.9	Summary .....	47
CHAPTER 3: METHODOLOGY .....		48
3.1	Introduction .....	48
3.2	The Concept of Research .....	48
3.3	Research approaches or strategies.....	48
3.4	Research Styles .....	51
3.5	Validity and Reliability .....	54
3.6	Sampling.....	56
3.7	Research Design.....	57
3.8	Summary .....	57
CHAPTER 4: FINDINGS.....		58
SECTION A: Case study findings .....		58
4.1	Summary of findings.....	67
4.2	Accident causation theories that appeared most frequently .....	68
4.3	Accident causation theories that appeared least frequently .....	69
4.4	Total occurrence of each type of cause .....	71
SECTION B: Questionnaire findings.....		72
4.5	Effectiveness of accident investigation processes.....	72
4.6	Improving accident investigation processes.....	73
4.7	Remedial action.....	74
4.8	Summary .....	76
CHAPTER 5: CONCLUSION AND RECOMMENDATIONS .....		77
5.1	Introduction .....	77



5.2 Summary .....	77
5.3 Hypotheses Testing .....	78
5.3 Conclusion.....	80
5.4 Recommendations .....	81
REFERENCES.....	82
ANNEXURE A: INFORMED CONSENT LETTER.....	90
ANNEXURE B: QUESTIONNAIRE .....	94
ANNEXURE C: ETHICAL CLEARANCE .....	97
.....	98

## LIST OF TABLES

Table 2.1: Social Readjustment Rating Scale of Holmes and Rahe .....	20
Table 4.1: System of referencing Theories and Models of Accident Causation.....	59
Table 4.2: Correlation of construction accidents causes against accident causation theories...	61
Table 4.3: Number of construction accidents that occur a month.....	72
Table 4.4: Presence of an accident investigation process.....	72
Table 4.5: Effectiveness of accident investigation processes.....	72
Table 4.6: Improvement suggestions of accident investigation processes.....	73
Table 4.7: Impact of improved accident investigation processes on H&S performance.....	73
Table 4.8: Perception of effectiveness of accident investigation processes.....	74
Table 4.9: Identification of remedial action.....	74
Table 4.10: Effectiveness of remedial actions.....	75
Table 4.11: Remedial action assessed for effectiveness.....	75
Table 4.12: Perception of fault for accident causation.....	75

## LIST OF FIGURES

Figure 2.1: Domino model of accident causation .....	22
Figure 2.2: Reason's Swiss cheese model .....	26
Figure 2.3: Accident Causation Model.....	27
Figure 2.4: Constraint-Response Theory.....	29
Figure 2.5: A graphic representation of examples of spheres of influence.....	31
Figure 2.6: Hierarchical model of socio-technical system .....	33
Figure 2.6: Boundaries of Safe Operation.....	33
Figure 2.7: Flaw classification .....	35
Figure 2.8: Hierarchy of Causal Influences in Construction Accidents.....	41
Figure 3. 1 Showing the depth and breadth in question-based.....	52
Figure 4.1: Summary of findings.....	67
Figure 4.2: Accident causation theories that appeared most frequently.....	68
Figure 4.3: Accident causation theories that appeared least frequently.....	69
Figure 4.4: Total occurrence of each type of cause.....	71
Figure 3.1: Showing the depth and breadth in question-based studies.....	51

## Definition of Key Terms and Concepts

**Accident:** An accident is an event or sequence of events that results in unintended harm in the form of injury, death or property damage and/or environmental pollution or degradation (Organisational Procedure, 2008; Hosseinian and Torghabeh, 2012).

**Accident investigation process:** The process or method used to identify the causes of accidents in order to reduce or eliminate accidents through interventions targeted at the identified causes (Hosseinian et al, 2012; Arboleda and Abraham, 2004; Suraji et al., 2001).

**Hazard:** An unsafe situation or act with potential harm that can lead to accidents, human injury or ill health (SAMTRAC, 2017).

**Lost time accident:** An accident that occurs in the workplace which renders the injured employee unable to continue working or causes a part of the construction project to come to a halt for a period of time thereby resulting in time lost and project delays (Organisational Procedure, 2008).

**Risk:** The potential or probable loss that exists in a situation, place or project. It is assessed either individually or combined depending on the type of risk or situation, place or project. (Mitropoulos, Abdelhamid and Howell, 2005)

**Safety:** The control of recognized hazards to obtain an acceptable level of risk (Mitropoulos, Abdelhamid and Howell, 2005); freedom from unacceptable risk of physical injury or of damage to the health of people, either directly, or indirectly as a result of damage to property or to the environment (IEC 61508 (1998-2000)).

**Near miss incident:** is an incident where damage to property or injuries to personnel could have been caused if there was a slight difference in time or position but by chance did not occur (Marks, Teizer and Hinze, 2014).

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

This chapter will include the Background, Problem statement, Hypotheses, Objectives, Methodology, and Structure of the study as well as the Limitations, Delimitations and Ethical Statement.

## 1.2 Background

The Construction industry has experienced many accidents involving loss of life and limb in South Africa which has consequently resulted in negative impressions of the industry and sector (CIDB, 2009). It is necessary to exam the causation of accidents considering the potential consequences of high casualty tolls, environmental damage, economic losses and ethical/moral considerations (Saleh and Pendley, 2012). It is well-known that construction represents a challenging regime in which to manage health and safety exacerbated by the enormous diversity in terms of the size and range of its activities (HSE, 2001). Poor health and safety (H&S) not only negatively affect employees lives which is always top priority, it also negatively affects project costs, quality, schedule and results in increased insurance premiums, medical costs and reduced productivity (Irizarry, Simonsen, and Abraham, 2005). Additionally, construction sites are hazardous working environments with direct exposure to many health risks and safety hazards that are not necessarily present in other industries or working environments. Improved H&S performance will lead to benefits such as increased efficiency, reduced delays, enhanced competitiveness, fewer disputes, increased profitability, and reduced conflict (Arboleda and Abraham, 2004).

Compared to manufacturing or retail environments which are relatively stable, construction projects typically involve constant change. To combat the negative consequences of these changes, legislators have by and large resorted to legislating for the numerous variations in the nature of construction projects. The expectation is that uniform H&S regulations should apply generically across the entire construction industry, from minor building renovations to major civil projects. The widespread use of various sub-contractors, self-employed workers and labour brokers has created a situation where multiple approaches and attitudes to construction H&S exist on the same site, resulting in an ineffective communication chain (HSE, 2001).

Resultantly, it becomes difficult for those responsible for the overall management of a project to manage H&S and integrate a wide variety of contractor ‘styles’ within the scope of a single project.

The findings of a study in South Africa in which 252 construction industry stakeholders participated suggested, *inter alia*, a need for the following, namely

- The enhancement of the H&S culture of the construction industry; and
- The realization and awareness that all construction accidents can be prevented (Smallwood and Haupt, 2004).

H&S improvements in the workplace are developed and shaped as a result of the knowledge gained and assumptions made from accidents that have occurred (Gibb, Lingard, Behm and Cooke, 2014). Understanding what causes accidents is important as it helps distinguish between factors that require attention and factors or corrective action that are insignificant and can be ignored as it will not prevent the accident from reoccurring (Swuste, 2008). There are a number of theories that exist created by scholars in attempts to provide understanding of the causation of accidents on construction sites. However, accidents have continued unabated despite these theories. Typically, these theories have been fixated on the construction worker as being the primary cause of accidents – a basic tenet of the behavioural safety approach supported by Krause and Hidley (1990) and others. The emphasis on individual failures resulted in a dependence on short-term, unsustainable solutions rather uncovering more fundamental organisational or managerial problems (Whittington et al., 1992). Generally, the recommended remedial action targeted a specific event in isolation, such that no effort was made to expose the underlying root cause of the accident. The HSE (2001) observed that changes at the direct level alone would not deliver the degree of change being sought, nor would the resultant improvement be sustained.

### **1.3 Accident causation theories**

There are a vast number of theories about the causes of accidents on construction sites that are typically regarded as dangerous and hazardous working environments (Smallwood and Haupt, 2001). Some of the better-known older theories include, for example, the following:

- Accident Proneness Theory
- Adjustment Stress Theory
- Goals-Freedom-Alertness Theory
- Distractions Theory
- Chain of events (Domino and Updated Domino theory)

Examples of the more recent accident causation theories include, for example, the following:

- Reason's Framework for Accident Causation;
- Constraint-Response Theory;
- Multiple Causation Model;
- Human Error Theories; and
- Systemic accident model
- Hierarchy of Causal Influences in Construction Accidents Model

Construction accidents are avertable and according to Hudson (2014) it should be regarded as failures of management. Historically, accident causation theories did not comprehensively address this matter. However, in line with the more modern accident theories, the aim of organisations should be to shift the emphasis from errors or negligence on the part of the individual to the management and organisational errors that cause poor H&S performance.

### **1.4 Problem Statement**

Currently, the causes identified in construction accident investigation records might be incorrect resulting in the subsequent preventative and remedial measures being misdirected, ineffective and unsustainable, the outcome of which will not necessarily be the prevention of the same accidents.

## 1.5 Research Hypotheses

**Hypothesis 1:** Accident investigations tend to focus on the worker being the primary cause of the accident.

**Hypothesis 2:** Accident investigations fail to identify upstream root causes of accidents that include failures of management and/or organisational errors.

**Hypothesis 3:** Corrective, preventative and remedial actions flowing from completed investigations derive from poorly designed accident investigation methods.

**Hypothesis 4:** Remedial measures arising from investigations will not prevent the recurrence of accidents.

## 1.6 Research Objectives

The primary objectives of the study are:

- From a sample of actual records and investigation reports of accidents at a major construction company, to identify the causes recorded of these accidents during the actual investigation process and classify them according to the various causation theories to determine the focus, namely worker or site management of each cause.
- To critically review each accident record and report to determine whether the proposed corrective action would address the actual root causes and would prevent the recurrence of the particular accident.
- From the review to propose corrective measures, if any, to improve accident investigation procedures to correctly identify root causes and propose appropriate preventive measures.



## 1.7 Research Methodology

- An extensive literature review on accident causation theories and models and methods of investigation was conducted.
- This study employs a qualitative research approach. This study employed the use of a combination of questionnaires and case study approach.
  - A combination of exploratory and collective case study was conducted on a sample of 30 accidents investigation reports which were drawn from the database of a large South African construction company and examined to determine their recorded causes. These were compared against the various accident causation theories to determine if the correct root causes and remedial action was identified and whether the same accident is likely to recur or not.
  - A survey of a small sample of 10 Contractors and Health and Safety Officers was conducted using a questionnaire which was aimed at determining if the results of the case study are in fact in line with what these professionals actually experience on site.
- The research design is based on quota sampling as a sample of any 30 lost time accidents reports were required from the participating large construction company for selection and analysis for this study and convenience sampling was used to obtain the sample of 10 Contractors and Health and Safety Officers.
- The findings from the analysed data will then be validated against the literature. Sustainable and effective interventions will be formulated from the analysis.

## **1.8 Limitations of the study**

The following limitations apply to the study, namely

- The study was confined to a large construction company where a number of construction projects have been undertaken and where actual construction accident investigation records were accessed.
- Timeframe was a limitation as this study had to be completed within a year.
- The accident investigation records to be analysed will consist of 30 cases of lost time construction accidents that occurred in a particular construction company.
- Not all accident causation theories were reviewed and analysed due to timeframe constraints.

## **1.9 Delimitations of the study**

The review that will be conducted on some of the various accident causation theories that exist will focus primarily on the theoretic components. There will not be in-depth examination of the behavioural components.

## **1.10 Assumptions**

- It was assumed that the providers of the actual accident investigation records will cooperate and provide the required documentation.
- It was assumed that the data recorded in each investigation record was accurate.

## **1.11 Ethical Considerations**

To comply with internationally accepted ethical standards, no reference to actual names of individuals or companies will be recorded. In this way, no individual or company can be linked to a particular accident, and therefore assuring anonymity.

## **1.12 Structure of Study**

### **Chapter One: Introduction**

This chapter will include the Introduction, Problem statement, Hypotheses, Objectives, Methodology, and Structure of the study as well as the Limitations, Delimitations and Ethical Statement..

### **Chapter Two: Literature Review**

This chapter comprehensively reviews all existing theories on accident causation to identify and understand what experts believe are the causes behind construction accidents. This chapter also aims to determine where the causal factors lay with regards to the effectiveness of the project management lifecycle in preventing an accident from reoccurring.

### **Chapter Three: Methodology**

This chapter comprises the theory behind research methodology and states the research methodology employed in this study to test the studies' hypotheses. This chapter will also discuss the sample and method of data collection to be used in this study as well as the method of analysis of data collected. Information on the reliability and validity of the data collected will also be provided.

### **Chapter Four: Data Analysis and Discussion of Findings**

This chapter consists of the presentation of data collected and the analysis of the data which will be focused on testing the hypotheses and responding to the research objectives. This chapter will discuss the key findings in comparison with the literature that was reviewed.

### **Chapter Five: Conclusion and Recommendations**

In this final chapter, conclusions will be drawn based on the findings of the study and effective and sustainable recommendations will be given.

### **1.13 Summary**

This chapter outlines the framework of the entire research study. It includes the background and significance of the research study, the problem statement, the hypotheses, objectives and research methodology to achieve these objectives. This chapter also includes the limitations, delimitations, assumptions and structure of the research study.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter presents a review of literature on various existing older and more recent theories of accident causation. It also seeks to identify what researchers suggest causes accidents as part of the effort to understand where the causal factors manifest in terms of the project management lifecycle model and its effectiveness in preventing an accident recurring.

### **2.2 Nature of the industry**

The construction industry is a broad industry that is well recognised for its key role in contributing to the economic growth and long-term national development of a country (Ofori, 2015). It contributes to the enhancement of a countries infrastructure and the maintenance thereof and it adds value to people's lives through the development of housing, schools, healthcare, facilities, and roads (Hosseinian *et al.*, 2012). The construction industry plays an important role globally, it sustains growth, provides employment for skilled, semi-skilled and unskilled workers and it is overall a necessity in modern society. However, for many workers and their families and friends, their involvement in the construction industry often leads to the tragic loss and unimaginable pain and suffering associated with an accidental death or injury (Lingard and Rowlinson, 2005). Construction workers continue to incur injuries and die every year at a higher rate than almost any other industry despite the establishment of occupational health and safety regulations. This dismal performance track record has left the construction industry with a bad reputation which has created negative impressions of the industry and sector (Hosseinian et al, 2012).

Construction represents a challenging regime in which to manage health and safety (CIDB, 2009) especially in terms of the enormous diversity with regards to the size and range of its activities. Construction projects involve constant change unlike the relatively stable manufacturing or retail industries. To combat the negative consequences of these changes, legislators have by and large resorted to legislating for the numerous variations in the nature of construction projects. The expectation is that uniform H&S regulations should apply

generically across the entire construction industry, from minor building renovations to major civil projects. The widespread use of various sub-contractors, self-employed workers and labour brokers has created a situation where multiple approaches and attitudes to construction H&S exist on the same site, resulting in an ineffective communication chain (HSE, 2001). Resultantly, it becomes difficult for those responsible for the overall management of a project to manage H&S and integrate a wide variety of contractors on the same project as well as different contractual arrangements within the overall project. It is suggested by Guadalupe (2002) that personnel that are 'temporary' employment are more likely associated with higher incidences of accidents than where personnel are permanently employed.

### **2.3 “Accident” versus “Incident”**

The poor H&S performance of the construction industry and its general lack of focus on the hazardous nature of construction activities is widely recognized and acknowledged (CIDB, 2009). In discussing accident prevention, it is important to clarify the terms "accident" and "incident." The term “accident” implies that the event was not expected, foreseen or intended sometimes resulting from negligence that results in injury, loss or damage (Asanka and Ranasinghe, 2015; SAMTRAC, 2017). Similarly, it is an unpleasant event that happens unexpectedly without advance planning and apparent cause and results in injury or damage (Asanka *et. al.*, 2015).

By referring to the term “accident”, an impression is created that it just happened, and that it was unexpected and unpreventable. It supports a mindset that a particular outcome was unavoidable. As a result, personal responsibility and accountability are seemingly removed and can potentially create a means to avoid rectifying the situation, dodge scrutinising current methods, and yield to pressure to change (Smallwood and Haupt, 2001). The accidents generally reported are only a portion of the total incidents that occur on construction sites. Some accidents may not be reported due to difficulties with communication, geological location, cultural barriers and governmental interference (Hämäläinen, Takala, and Saarela, 2006).

An “incident” is defined as a minor happening, an event or an occurrence, whether predictable or not, that takes place as a result of something else (Marks, Teizer and Hinze, 2014). Near misses are incidents that can be defined as unplanned events that occur which results in no loss, injury or damage but under different circumstances could have resulted in an accident with actual loss, injury or damage (Durnwald 2012). A study done by Marks, Teizer and Hinze (2014) state that if near miss incidents are reported, data collected and analysed there will be a significant improvement in accident prevention and overall health and safety in the construction industry. Near miss incidents are considered a leading indicator which when identified, reported and analysed enhances the ability to identify hazards, safety training required and performance metrics (*Ibid*). It is generally accepted that all injuries are preventable if the root or core events that lead to the injury are avoided. Therefore, in order to reinforce the principle of preventability, increased focus should be placed on near miss incidents than accidents to promote better overall H&S culture.

The same types of accidents occur repetitively in the construction industry around the world. Many of the construction hazards are well known. Despite extensive research on many of these hazards they seem to continue to occur with the same incidence of death, injury and illness. Statistically, it is generally understood where deaths, injuries and illnesses are most likely to occur in the construction industry than any other industry. However, the construction industry has been more than lethargic to learn from its mistakes and introduce interventions to prevent these outcomes (Lingard and Rowlinson, 2005).

## **2.4 Accident causation theories**

“The identification of the root causes of accidents through the use of accident investigation techniques such as the application of theories on accident causation can prevent construction accidents” (Hosseinian et al, 2012:2). Although many theories and models have been developed over the years, there is currently no general agreement on the causes of accidents. Theories or models of accident causation is required to examine the causes of accidents and the resulting consequences. These accident causation theories or models have been classified in several

ways. For example, Katsakiori, Sakellaropoulos and Manatakis (2009) classified accident theories and models as either:

- Sequential or event-based models: Cause and effect models that are linear in nature. These models refer to accident causation as the result of a sequence of discrete events that occurred in a specific temporal order.
- Human information processing accident models: These models use human behaviour and actions to describe accident causation or;
- Systemic accident models: These looks at the performance of the system as a whole and describes accident causation as an emergent phenomenon as it is a complex interconnected network of events that exist in a specific time and space coincidentally and should be expected.

Accidents have been classified according to accident causation models such as multiple causation theory, domino theory and human error theories that include Ferrel theory, behaviour models and human factor models by Abdelhamid and Everett (2000). It has been claimed by Howell, Ballard, Abdelhamid and Mitropoulos (2002) that none of these theories or models provides an understanding of accident causation that is significant enough to prevent accidents that now plague the construction industry and refer to:

- Behaviour models where the fault lies solely with the worker and refers to the unsafe or negligence behaviour as a human characteristic; and
- Human factors model is similar to behaviour models where human error is the main cause of accidents, but it includes tasks and the design of the workplace that do not consider human limitations.

Mitropoulos, Abdelhamid and Howell (2005) created a model, which according to them, takes a systems view and focuses on the level of activity in relation to the production system and the variables that interact to generate tasks and shape work behaviours. Their model aims to reduce task unpredictability and to improve error management capabilities.

It is argued that accident causation theories used effectively can identify the causes of accidents and reduce or eliminate construction accidents through interventions targeted at the identified causes (Hosseinian et al, 2012; Arboleda and Abraham, 2004; Suraji et al., 2001). Abdelhamid



and Everett (2000) claim that prevention efforts or corrective action could be directed at the root causes of accidents and not at the direct or trigger causes, resulting in the improvement of accident prevention methods. The theories provide theoretical frameworks to guide the retrospective analysis of accidents and the prospective identification of hazards (Lehto and Salvendy, 1991). However, accidents have continued unabated despite these theories. Typically, these theories have been fixated on the construction worker as being the primary cause of accidents – a basic tenet of the behavioural safety approach supported by Krause and Hidley (1990), Geller (2001a, 2001b), Toole (2002), Suraji et al., (2001), Abdelhamid and Everett (2000), and Austen (2006). The process of accident investigation typically involves the writing up of a brief narrative description of what actually occurred with some information about the accident being recorded in different categories (Arboleda et al., 2004) - a somewhat backward-looking approach designed to determine the facts surrounding accidents and identifying root causes and contributing factors to the accidents (Saleh and Pendley, 2012). The findings of these investigations tend to point the finger at failures or causes resulting from actions or non-actions on the part of workers (Ibid).

The emphasis on individual failures resulted in a dependence on short-term, unsustainable solutions rather uncovering more fundamental organisational or managerial problems (Whittington et al., 1992). Generally, the recommended remedial action targeted a specific event in isolation, such that no effort was made to expose the underlying root cause of the accident. The HSE (2001) observed that changes at the direct level alone would not deliver the degree of change being sought, nor would the resultant improvement be sustained.

As previously stated, accidents are preventable and should be regarded as failures of management. Few of the current theories comprehensively addressed this view, largely because of the intrinsic litigative aspect of accident causation, which invited a retrospective approach to identify the guilty party or ‘culprit’ and distribute punitive measures (Shavell, 1979). However, in line with the modern accident causation theories that examined both proximal accident and distal causal factors (Manu, Ankrah, Proverbs and Suresh, 2010), organisations should aim to shift the focus from individual errors and negligence to management and organisational errors that cause accidents and ultimately poor H&S performance. These contemporary theories provide a systemic approach to identify underlying root causes of accidents while also taking

into consideration the decisions and actions upstream of the accident event. This forward-looking approach seeks to identify and eliminate causes and mechanisms of failure. Typically, accidents involved any combination of system design and technical flaws, operational or workforce failings, compromised organizational behaviours and management shortcomings, and/or deficient regulatory oversight (Saleh et al., 2012).

There are many accident causation theories. It is beyond the scope of this study to discuss each and every theory that exists. However, a few of the better-known older theories and newer ones will be discussed briefly. These are, namely:

- Accident Proneness Theory;
- Goals-Freedom-Alertness Theory;
- Adjustment-Stress Theory;
- Distractions Theory;
- Chain of events (Domino and Updated Domino theory);
- Multiple Causation Model;
- Reason's Framework for Accident Causation;
- Constraint-Response Theory;
- Human Error Theories; and
- Systemic accident model

Each of these theories and models will be discussed in the following section.

#### **2.4.1 Accident Proneness Theory**

Accident Proneness Theory is a common theory that focuses on personal factors related to accident causation. It is based on the assumption that some people would be more likely than others to sustain an injury when placed in similar working conditions which suggest that accidents are not randomly distributed. There are two views, namely an older and newer view (Hinze, 2006),

The older view suggests that people who have a genetic predisposition to be injured will get injured (Klumb, 1995). In terms of this view, certain individuals have inherent characteristics that inclines them towards a greater probability of being involved in accidents (Farmer and Chambers, 1929, 1933 and 1939; Shaw, L and Sichel, H.S, 1971). This view is no longer favoured (Hinze, 2006).

On the other hand, in terms of the newer view, accident proneness is associated with the propensity of individuals by way of a personality trait to take risks or to take chances (Dahlbäck, 1991). Accident proneness might then change over time, since risk taking is not an intrinsic or fixed trait. This view is more optimistic for the management of H&S as it suggests that a risk-taking personality trait and behaviour can be altered through training and proper motivational techniques.

#### **2.4.2 Goals-Freedom-Alertness Theory**

This theory, which was first suggested by Kerr (1957), suggests that accidents are caused by unsafe behavior as a result of workers being under stimulated by the tasks they are carrying out which results in an unrewarding psychological climate that does not contribute to a high level of mental alertness. According to Kerr (1957), accidents are therefore attributed to low-quality work behaviour occurring in an under stimulating work environment.

The theory holds that management should let a worker have a well-defined goal and give the worker the freedom to pursue that goal. The result will be that the worker focuses on the task that leads to that goal. Workers must have opportunities to participate in raising problems and solving them. According to Kerr (1957) such participation would lead to alertness habits that would in turn promote high quality production, safe behaviour, and fewer accidents.

According Hinze (2006), supervisors and managers should be trained to make the work environment more rewarding for the workers to ensure mental alertness. This can be done by giving workers incentives such as clearing work assignments, through managerial techniques such as participative management and through simple positive reinforcement and goal setting.

### 2.4.3 Adjustment-Stress Theory

Kerr (1957) developed a second theory, the adjustment-stress theory, to explain accident causation. This theory states that temporary conditions that imposes stress which diverts the attention of workers compromises H&S performance. The adjustment-stress theory was developed to complement the goals-freedom-alertness theory, in that the goals-freedom-alertness theory states fulfilling, or positive work environment will contribute to workers being safer, and the adjustment-stress theory outlines the conditions under which a worker will be unsafe (Hinze, 2006).

The likelihood of the occurrence of an accident is increased with an increase in negative stresses imposed on an individual which can either be internal environmental stresses such as, for example, lack of sleep; fatigue; psychological stresses such as worry or personal problems; or by the external environmental stresses such as noise; excessive physical strain will increase accident occurrence or excessive temperature. If the worker cannot adapt to the stress – the worker’s attention will be diverted during working hours and the chance of injury will be escalated.

According to the theory, factors that divert attention and increase the probability of an accident may be brought to the job or generated on the job.

- Factors Generated on the Job

Practices and policies of managers are often the source of on-the-site job stress and are the easiest for management to minimise and control (Hinze, 2006). Such mental diversions and stress may arise from, *inter alia*:

- Unrealistic demands placed on workers which include pressure to keep costs below some level that may not be realistic,
- Pressure to meet an unrealistic deadline;
- Pressures related to threats to job security;
- Poor relationship with supervisor;
- Poor relationship with team members;

- Poor co-ordination;
  - Excessive rework;
  - Cost overruns;
  - Long overtime commitments;
  - Crowded work areas; and
  - Workers being asked to work in an obviously unsafe environment (Hinze, 2006).
- Factors brought to the Job

Stress on workers may be brought to the job and may affect the worker's ability to remain safe in the workplace. These factors may be difficult for management to detect. Such examples include:

- Family: poor relationship with the spouse; death of a loved one; illness of family member; and financial problems; and
- Personal: substance abuse; poor health; fatigue and lack of sleep.

#### **2.4.4 Distractions Theory**

The Distractions Theory, according to Hinze (1996), has a narrow site-based focus and draw a parallel productivity with risk. It predicts that workers under stress working in an environment that is hazardous have a greater probability of being involved in accidents. The hazards distract workers when they are performing their work tasks and increase the probability of accidents and decrease productivity (Hinze, 1996, 2006; Mitropoulos, Abdelhamid and Howell, 2005). H&S and productivity are compatible when hazards are removed resulting in a decrease in distractions (Peckitt, Glendon and Booth, 2004). There are two main types of distractions, namely:

- Unsafe Physical Conditions (Site hazards)

When distractions due to a high number of hazards are present, productivity is compromised. Obviously, when the hazard level is high, it is expected that the worker will have a high level of hazard awareness (Hinze, 2006). The attention paid to hazards and the avoidance of being

injured, becomes a distraction for the worker. An injury might occur if pressure to get the task done causes the worker to be distracted and to ignore the hazard.

- **Mental Distractions**

Workers will try to focus on the work to be done but may be distracted by worries caused by personal problems such as, for example, financial worries, divorce, and family disputes or job-related concerns such as, for example, tight deadlines and unduly close supervision. Even positive events can be contributing factors to mental distractions, such as, parties, celebrations, paydays and going on holiday. The likelihood of being injured is increased by the failure to focus on the work and associated hazards (Hinze 1996, 2006).

- **Mental Stresses**

Holmes and Rahe (1967), two early psychological researchers of such events, examined the relationship between various life stresses and the onset of illness. Their work followed that of others who had provided evidence that stressful life events played a strong causative role in the onset of diseases (Hinze, 1996, 2006).

Stress was evoked by both negative and positive events. Holmes and Rahe (1967) and Rahe (1968) developed a scale of stressful events in which each type of event was given a value. The values of all the events that applied to a person were summed up. The higher the final score the higher the stressful condition and the higher the likelihood of contracting an illness. The scoring might be similarly applied to the distractions theory (Hinze, 1996, 2006). The Holmes and Rahe Scale as shown in Table 2.1 lists various potentially stressful events and the scores assigned to each.

#### **2.4.5 Chain of events (Domino theory)**

An engineer working for a USA insurance company by the name of Heinrich, conducted an analysis of 75,000 accident reports and attempted to develop a model that explains casual factors of an accidents that lead to injuries (Heinrich, 1959). He theorized that an accident is caused by one of five factors in a sequence that resulted in an accident. Accidents are therefore characterized as occurrences that result from a sequence of events that occur in a specific order

in that each event is consequently followed by another event (Taylor, Easter and Hegney, 2004; Hollnagel, 2002; Abdelhamin and Everett, 2000). The theory which is classified as a sequential accident or event-based model (Hosseinian et al., 2012.) and was compared to dominos falling, that is if one event occurred, it would trigger the cause of the next event which will resulting cause another event and so on. This theory portrays the concept of how accidents occur.

According to Hosseinian et al. (2012) the last event is the accident itself is invariably caused by a mechanical or physical hazard or the unsafe act of a person. The chain of events theory proposes that there are many causes to an accident rather than just a single cause. Heinrich's 'dominos' were as shown in Figure 2.1.

- *Ancestry and social environment.* This refers to the social background and influence of family that leads someone directly to...
- *Fault of person.* The refers to personal attributes such as greed, stupidity, and recklessness could be in the nature of a person or learned which leads directly to...
- *Unsafe act and/or mechanical or physical hazards or conditions.* This refers to the behaviour of workers that is unsafe and the unsafe conditions that may be as a result of the presence of mechanical or physical hazards which leads directly to...
- *Accidents.* These refers to events such as falls, collisions, etc., which leads directly to...
- *Injuries.* These could be sprains, lacerations, sprains, fractures and broken or dislocated bones etc. (Lingard, *et. al.*, 2005; Abdelhamid and Everett, 2000).

**Table 2.1 Social Readjustment Rating Scale of Holmes and Rahe**

<b>Life Event</b>	<b>Value</b>
Death of spouse	100
Divorce	73
Marital separation	65
Jail term	63
Death of close family member	63
Personal injury or illness	53
Marriage	50
Fired at work	47
Marital reconciliation	45
Retirement	45

<b>Life Event</b>	<b>Value</b>
Change in health of family member	44
Pregnancy	40
Sex difficulties	39
Gain of new family member	39
Business readjustment	39
Change in financial state	38
Death of close friend	37
Change to different line of work	36
Change in number of arguments with spouse	35
A large Mortgage	31
Foreclosure of mortgage or loan	30
Change in responsibilities at work	29
Son or daughter leaving home	29
Trouble with in-laws	29
Outstanding personal achievement	28
Wife begins or stops work	26
Begin or end school	26
Change in living conditions	25
Revision of personal habits	24
Trouble with boss	23
Change in work hours or conditions	20
Change in residence	20
Change in schools	20
Change in recreation	19
Change in religious activities	19
Change in social activities	18
A Small Mortgage	17
Change in sleeping habits	16
Change in number of family get-togethers	15
Change in eating habits	15
Vacation	13
Christmas	12
Minor violations of the law	11



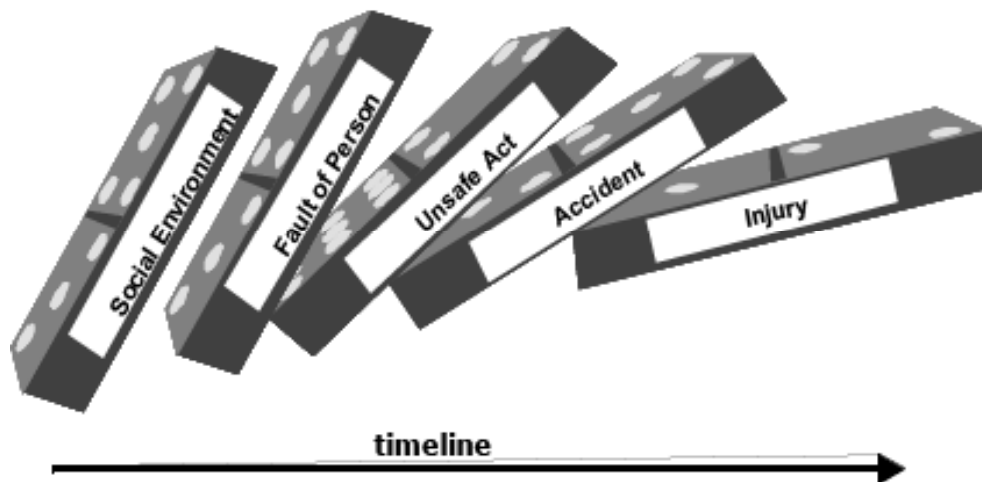


Figure 2.1. Domino model of accident causation (Adapted from Hosseinian *et. al.*,2012).

According to Heinrich (1959) 88% of accidents were caused by unsafe acts, and only 10% were caused by unsafe conditions. The domino theory held, therefore, that unsafe behaviour of people were the fundamental reason behind accidents. Viner (1991) suggests that this theory is supported by many people who take the view that accidental injury is the consequence of the injured behaving in a way that disregards accepted behavioural norms. Many programs aimed at the prevention of occupational accidents still focus efforts to reduce or eliminate the immediate behavioural causes of accidents by attempting to change worker's behaviour (Lingard, *et. al.*, 2005). Heinrich's Domino Theory has faced much criticism for focusing too extensively on the immediate causes or circumstances surrounding accidents and the role of human behaviour in accidents (Hopkins, 1995; Howell, Ballard, Abdelhamid and Mitropoulos, 2002), when it now recognised that unsafe acts and conditions have systemic and organisational causes (Lingard, *et. al.*, 2005). According to Hollnagel (2002) and Goh, Brown and Spickett (2010), accidents should not merely be attributed to either an unsafe condition or an unsafe act because most accidents are the result of a complex interaction of multiple contributing factors, causes and sub-causes. Therefore, the accident causation model developed by Heinrich as well as other behaviour models is over-simplified.

- An Updated Domino Theory

The Chain of Events (Domino) theory of Heinrich was later revised by Bird (1974) by integrating the role of management in the accident causation process. Accident causation and the resultant losses such as injuries, fatalities and even the damage to property and wastage of the organisation's assets can be traced back to management negligence and lack of control. The revised sequence sets out the dominoes as follows:

- *Lack of control by management of root causes*: This leads to...
- *Basic contributing causes of accidents*: This refers to personal factors, such as lack of motivation, fatigue or insufficient H&S knowledge. It could also be job factors like unrealistic work schedules and inadequate or insufficient resources, for example which lead to...
- *Immediate or direct causes of accidents*: This refers to sub-standard practices, conditions, hazards or errors, which lead to...
- *The accident*: This refers to falls, collisions, tripping, etc. which results in...
- *The loss or injury*: This can be minor, serious or catastrophic and could lead to fatalities, loss of limb, damage to property, delays in project, increased costs etc.

In general, there are preceding series of events to every accident. If any one event or activity had been altered or done differently in the series of events, then the accident would not have possibly not occurred. Put another way, any one event in a chain that did not occur would break the chain or sequence and prevent the accidents. Each link in the chain may involve different people and be associated with different activities and only one link in the chain need to break in order to prevent the accident from occurring according to Heinrich (1959) and Bird (1974).

However, according to Hinze (2006), accidents are too often blamed on the event that occurs most proximal in time or place to the accident. This last event is typically some action performed by the worker. It is, therefore, common for many injuries to be blamed on worker behaviour. It is important to consider the other events in the chain, not just the final action of the worker who becomes injured. To simply blame the injured workers for many of their injuries and only identify corrective focused on eliminating the last event in the chain, is

basically ignoring the roles that other parties play in influencing worker behaviour (Hinze, 2006).

A study was conducted at the Naval Surface Weapons Centre in Silver Spring, Maryland in the U.S.A. where the concept of the chain of events theory was applied (Hinze, 2006). The study focused on the role of management in accidents and was based on the premise that all accidents and hazards are indicators of management failures (Fine, 1975). The hypothesis for the study was “In the investigation of any accident, there can always be found some degree of management involvement or activity that might in some way have prevented the accident”. Therefore, it was arbitrarily assumed that responsibility of causes of every accident will be for managements account, as well as for the existence of every hazard.” Accidents were investigated to seek out the means that might have been available to management to change the course of events so as to avert the accident.

This Navy study included accident investigations with clear cut causes. Managerial opportunities to either minimise or avoid the hazards began to emerge. When each accident or hazard had been carefully evaluated, nearly every investigation revealed a failure of management. Once management recognised its failures, it was in a position to correct and prevent them. The effect of the corrective measures proved to be positive from an economic point of view, health improved at the facility, and there was higher productivity. In the long term, this acceptance of responsibility by management resulted in overall reductions in the costs of the Navy operations.

With reference to construction projects, there are various parties that are involved, such as, for example, clients/owners, designers, principal contractors and sub-contractors. According to the chain of events theory, each party could play a role in the causation of an accident in which a worker is injured. Conversely each party could play a role in preventing a series of events that could otherwise lead to an accident (Hinze, 2006). No party can take the view that health and safety was someone else’s responsibility. Every party plays a role. The owner does have control over the players in a project, by setting the tone for that project and it does not imply that the owner is responsible for everything that happens on the project, regardless of the actions of the other parties involved (Hinze, 2006).

Bird and Loftus (1976) claim that the traditional focus on direct or immediate causes of accidents in accident prevention involves treating the symptoms of the problem rather than their underlying root causes. Accidents will continue to occur if long term solutions do not focus on management control and errors of management which is the first domino in the sequence of events.

#### **2.4.6 Multiple Causation Model**

According to Peterson (1971), the theory of multi causality states that there are more than one event or even multiple events that precede every accident. Contributing causes also play a role in accident causation as they combine together randomly resulting in an accident. Using as an example of a common accident scenario of a man falling off a defective stepladder; present accident investigation approaches will most likely identify it only one act (climbing a defective ladder) and/or one condition (a defective ladder) (Petersen, 1971). Corrective action for this accident would be to discard the defective ladder to prevent it from being used again. If Domino Theory was used, this would be the typical response to the investigation but by using Multiple Causation Theory, the surrounding factors such as lack of supervision would have been evident (Petersen, 1971).

Accident investigation processes or methods that attempt to uncover only the unsafe act or the condition is only successful with mitigating the symptoms of the problem, as they may be the “immediate/proximate causes” and not “root causes” (Abdelhamid and Everett, 2000). In order to have permanent improvement and to prevent the same accidents from reoccurring the root causes must be identified. As stated by Bird and Loftus (1976), root causes often relate to the first event in the chain of events which relate to errors of management and may be due to, for example, management policies, procedures, supervision, effectiveness, and training.

**2.4.7 Reason’s Epidemiological Model**

Reason’s Epidemiological Model on accident causation covers the entire accident sequence from errors of management to worker’s unsafe behaviour and conditions. This theory is similar to the Multiple Causation theory as it also follows more of a current approach and looks at causal factors other than only the immediate causes. Unlike traditional accident causation models which highlighted the role of workers as the most obvious immediate instigators of accidents, Reason’s theory analyses the causes of accidents by incorporating factors at the organisational level, taking into account the input of management and decision-makers. This is what the Swiss cheese model of accident causation in Figure 2.2 is based on. Most H&S management systems have a number of layers or plates. Due to human error these plates had holes which allowed for the potential incident to pass through the plate or layer of the H&S system. More often than not, the next plate or layer intercepted the potential incident and prevented its occurrence. However, when holes lined up the incident was more likely to occur. The model divided failures into two categories, namely active and latent failures as shown in Figure 2.3.

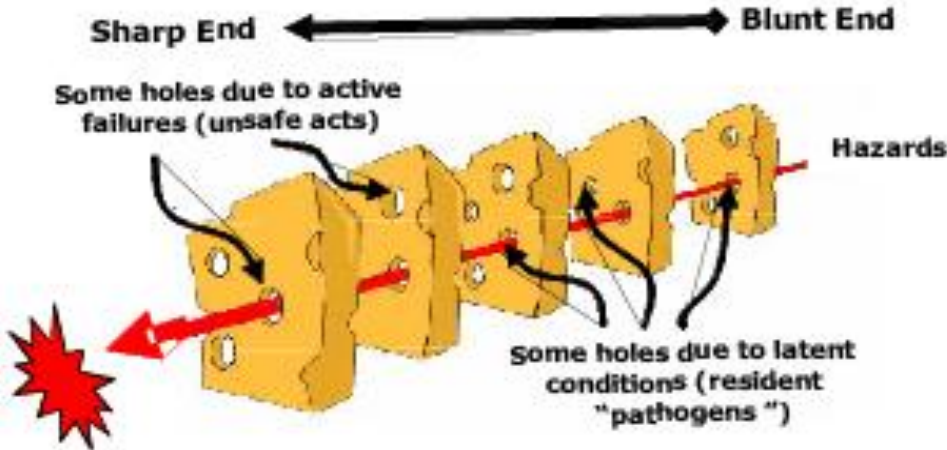


Figure 2.2. Reason’s Swiss cheese model (Adapted from Qureshi, 2007)

Active failures are associated with the activities of ‘frontline operators’ or workers which involved errors and violations that had an immediate adverse effect. These active failures corresponded to the activities of construction workers on-site such failing to wear personal protective equipment or making contact with overhead power lines (Reason 1990).

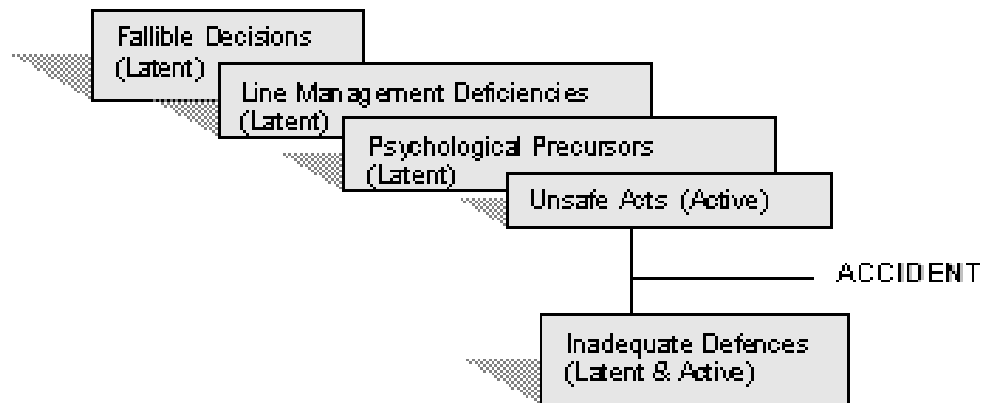


Figure 2.3. Accident Causation Model (Reason, 1990)

Many health and safety interventions targeted the general operative such as, for example, training programs to promote the wearing of personal protective equipment such as hard hats, gloves, safety shoes etc. and to promote hazard awareness and other interventions such as instituting health check campaigns and inspections. However, due to the complex nature of construction projects, an infinite number of H&S hazards and risks exists on construction sites. Most of these hazards were occasionally quite bizarre and difficult to anticipate or predict (Reason, 1990). Therefore, it would be a very time consuming and nearly impossible task to determine every H&S hazard and unsafe act on site and attempts to reduce the number of these hazards and unsafe acts would only have limited value. Therefore, according to Reason (1990), aiming to mitigate latent failures would be more beneficial.

Latent failures refer errors of management and organisations and specifically to their actions or decisions which leads to detrimental consequences of which may lie dormant for a long time until combined with a local triggering factor that results in an accident. Latent failures are attributed for existing in the system long before the onset of a recognisable accident sequence (Reason 1990). Research by the HSE (1992) found that poor management decisions in which H&S goals might have been considered less important than production goals resulting in the creation of the prerequisites of unsafe behaviour. This research also noted situations where roles and responsibilities were ambiguous and ill-defined, training and induction programs were poorly design and ineffective and where time pressures were high, violations were known to occur more frequently.

## 2.4.8 Constraint-Response Theory

A causal model specific to construction accidents was developed by Suraji, Duff and Peckitt (2001) of University of Manchester Institute of Science and Technology (UMIST) and the Health and Safety Executive in the United Kingdom. Reason's model was cited in the Constraint-Response theory but the lack of specific detail necessary to guide practical investigation and corrective action was noted. Knowledge of which causal factors were most influential, who should control those factors and how control of those factors can be most effectively achieved would aid in the effective mitigation of causal factors (Suraji, Duff and Peckitt, 2001).

Similar to Reason's model, the Constraint-Response Model includes management and organisational aspects in accident causation. It mapped the potential contributions of all participants within the project organisation to the accident causation process. Similar to the classification of accident causation into active and latent failure referred to in Reason's model, Constraints-Response theory is classified into two types of factors, namely distal and proximal, shown in Figure 2.4.

Distal factors were at management level and included:

- Project conception constraints;
- Project design constraints;
- Project management constraints;
- Construction management constraints;
- Sub-contractor constraints; and
- Operative constraints (Suraji, *et. al.*, 2001).

These precipitated potentially unsafe responses by clients, designers, the project team of clients, principal contractors, sub-contractors and operatives. These constraints and responses included the influence of management and organisational factors; environmental factors such as economic, legislative, political and social; and individual participant factors.

Proximal factors, on the other hand, operated at site management and injured person levels and included:

- Inappropriate construction planning;
- Inappropriate construction control;
- Inappropriate site condition;
- Inappropriate construction operation; and
- Inappropriate operative action (Suraji, *et. al.*, 2001).

These could be identified as immediate causes of construction accidents.

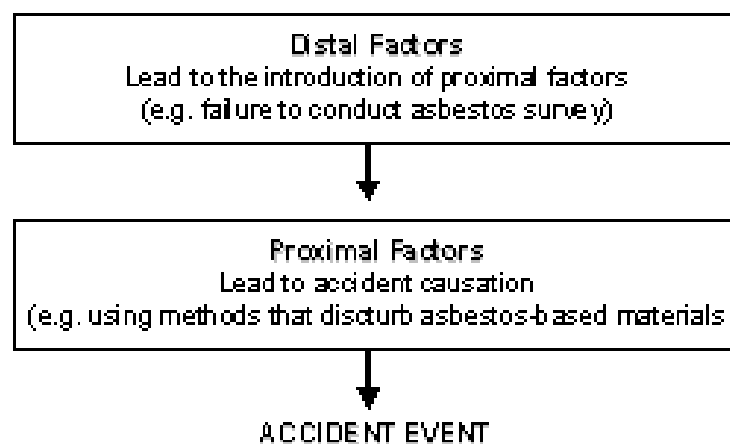


Figure 2.4. Constraint-Response Theory (Suraji, Duff and Peckitt, 2001)

This theory suggested that constraints are experienced by all participants on their activity which in turn has a knock-on effect on other subsequent participants, for example, a client is experiencing difficulty in obtaining additional funding for a construction project. The knock-on effect will be that the client may have reduced the project budget subsequently leaving the architect with an insufficient design budget. The architect may be forced to reduce resources or opt for cheaper options for the project that may compromise quality. The project management team may, in turn, be constrained by late delivery due to insufficient resources and the reduced quality may lead to further complications and delays, and so on throughout the project chain. This knock-on effect creates a sequence of constraints which ultimately creates situations where the proximal factors manifest such as inappropriate site conditions and inadequate supervision and construction control.



### **2.4.9 Human Error Theories**

Human error theories were best captured in behaviour models and human factor models. Behaviour models identified the workers as being the primary cause of construction accidents. This model mostly places blame on human behaviour and unsafe characteristics. It studies the tendency of individuals to act in an unsafe manner and make errors under various situations and environmental conditions (Abdelhamid and Everett, 2000). Rigby (1970) described human error as any human action that exceeds some limit of acceptability. Many researchers have devoted much time and effort to defining and categorising human error (Abdelhamid and Everett, 2000).

Similar to the behavioural models, the human factors approach held that human error was the primary cause of accidents (Rasmussen, 1997). However, this model not only attributes accident causation to unsafe human behaviour and characteristics it also faults poorly designed workplaces and tasks that do not consider human limitations that could result in detrimental effects. Therefore, the ultimate objective of the human factor approach was to introduce better designed tasks, tools, and workplaces that acknowledged the limitations of human physical and psychological capabilities (Abdelhamid and Everett, 2000).

### **2.4.10 Systemic accident models**

A system in the context of construction is not static but dynamic and continually changing to achieve scheduled milestones while reacting to a changing environment. Systemic accident models describe an accident as a complex and interconnected network of events and consider the performance of the system as a whole. Qureshi (2007) views accidents as a phenomenon that arise from interactions among system components such as physical system components people, engineering activities social and organizational structures. According to this theory, accidents do not occur in isolate but are rather part of a larger system of causal factors or sphere of influence. This concept forms the foundation on which the systems approach to understanding and managing risk is based on, it considers all events or activities within the context of sphere of influence, such that no one event can be viewed in isolation from its surrounding context. These causal factors may be human, technical and environmental.

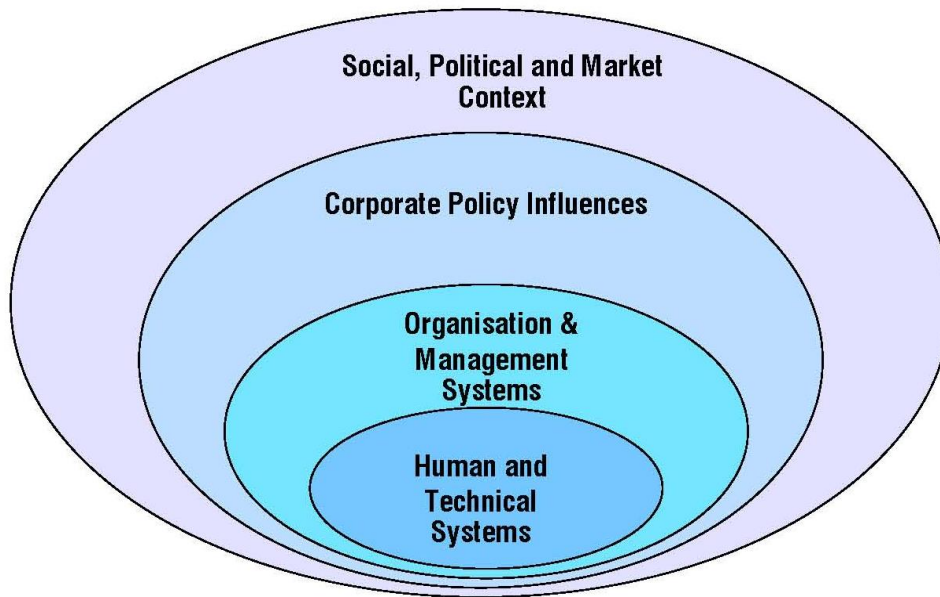


Figure 2.5. A graphic representation of examples of spheres of influence

Examples of these spheres of influence that influence the performance of people and hardware in a hazardous situation are shown in Figure 2.5. These influences can either be internal to the organization or external to the organization. For example,

- Direct level influences would include, inter alia, the following, namely
  - Level of competence;
  - Motivation or morale;
  - Fatigue or level of alertness;
  - Equipment operability;
  - Situational awareness or risk perception;
  - Inspection and maintenance;
  - Level of information or advice available; and
  - Workplace environment.
  
- Organizational level influences would include, inter alia, the following, namely
  - Training;
  - Planning;
  - Management and supervision;

- H&S culture; and
- Inspection and maintenance.
  
- Policy level influences would include, inter alia, the following, namely
  - Contracting policy;
  - Company culture;
  - Organizational structure;
  - H&S management;
  - Labour relations; and
  - Profitability.
  
- Environmental level influences would include, inter alia, the following, namely
  - Political;
  - Regulatory framework;
  - Market conditions; and
  - Societal.

The creation of corporate culture that manifests in organisations and refer to regulatory policies, poor organisational practices, and societal influences that have played a significant part in developing latent conditions that result in the occurrence of accidents. However, unacceptable H&S acts and latent conditions in general within the workplace are not seen as causal factors but rather the consequence of organisational. The identification of underlying root causes is the most significant aspect in accident prevention although the immediate causes are also important in understanding the circumstances surrounding an accident, it does not contribute significantly to accident prevention.

Rasmussen's (1997) hierarchical socio-technical framework endeavours to model the dynamics of complex sociotechnical systems. Pressures and constraints associated with work processes impacts the performance of H&S in the operational environment. Several hierarchical levels are involved as shown in Figure 2.6.

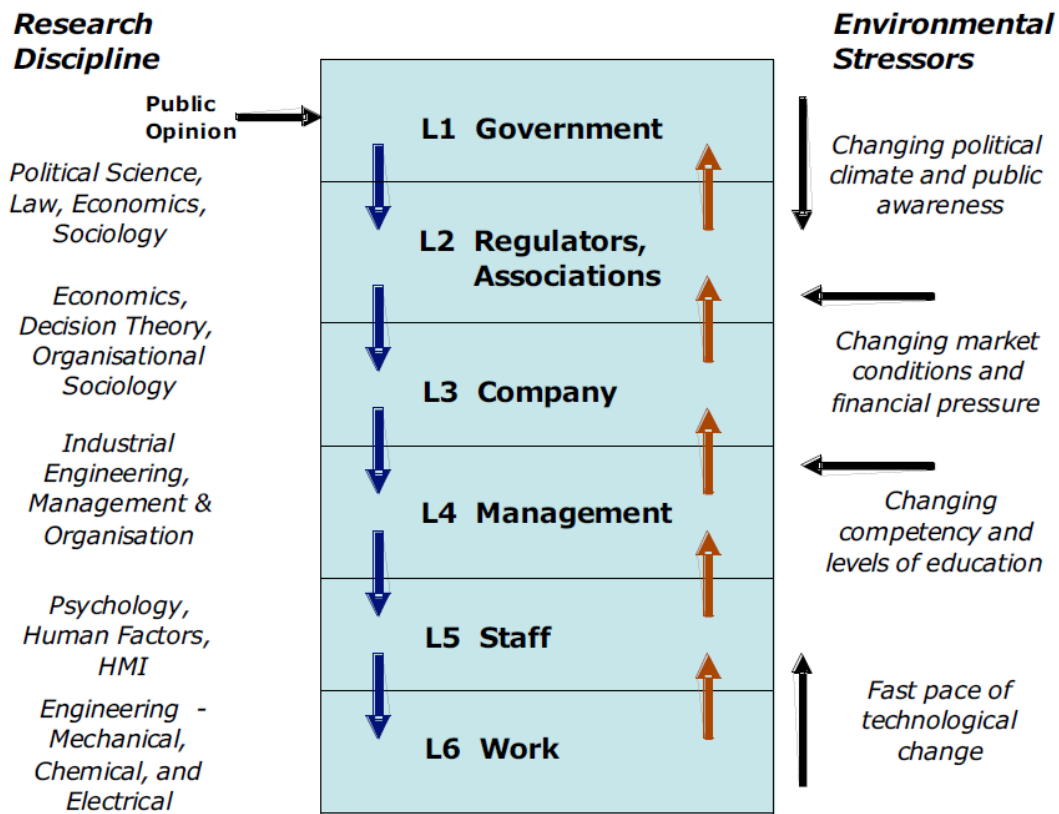


Figure 2.6: Hierarchical model of socio-technical system (Adapted from Qureshi, 2007)

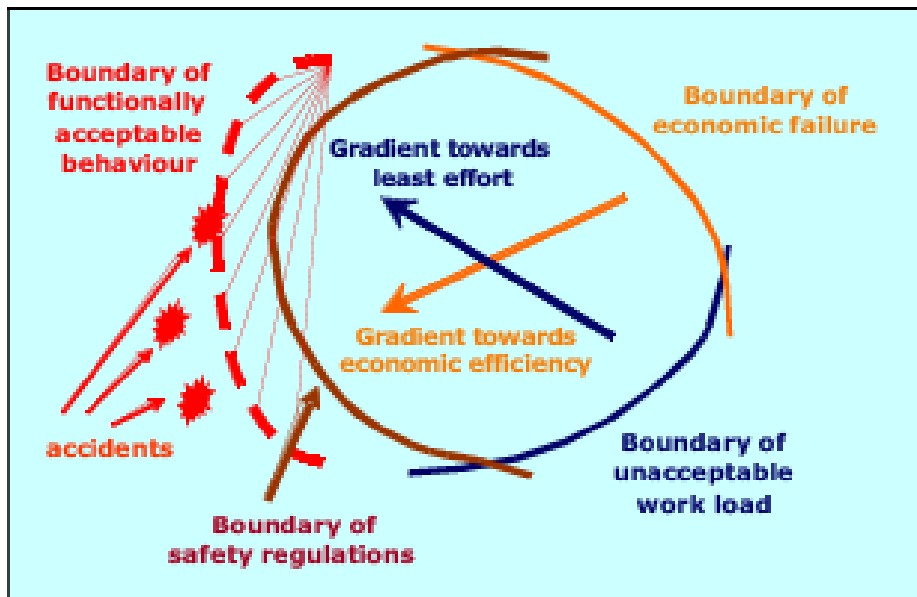


Figure 2.7: Boundaries of Safe Operation (Adapted from Qureshi, 2007)

Vicente (1999) posits worker's behaviour depends on the context and is shaped by every changing conditions of the construction work environment. According to Rasmussen (1997), the boundaries of H&S operations and the dynamic forces that affect the system and may cause the system to migrate towards those boundaries possibly crossing it must be identified in order to analyse the H&S of a work domain or environment. Figure 2.7 it is evident that dynamic forces can cause a system to modify its structure and behavior over time. The safe space of performance within which workers and management can navigate freely is contained within three boundaries, namely individual unacceptable workload; financial and economic constraints; and H&S regulations and procedures. As people are subjected to dynamic forces they adapt their behavior and cross the boundaries that might lead to an accident if control is lost at the relevant boundary. Therefore, there is a need to identify the boundaries of H&S operation, make these boundaries visible to everyone and create opportunities to control behavior at the boundaries.

Leveson (2004) considers the technical, human and organizational factors in complex socio-technical systems in his Systems-Theoretic Accident Model and Processes (STAMP). Accidents are caused by inappropriate or inadequate control or enforcement of H&S-related constraints rather than by discrete events and are therefore viewed as a control problem. H&S is therefore managed by a control structure embedded in an adaptive socio-technical system.

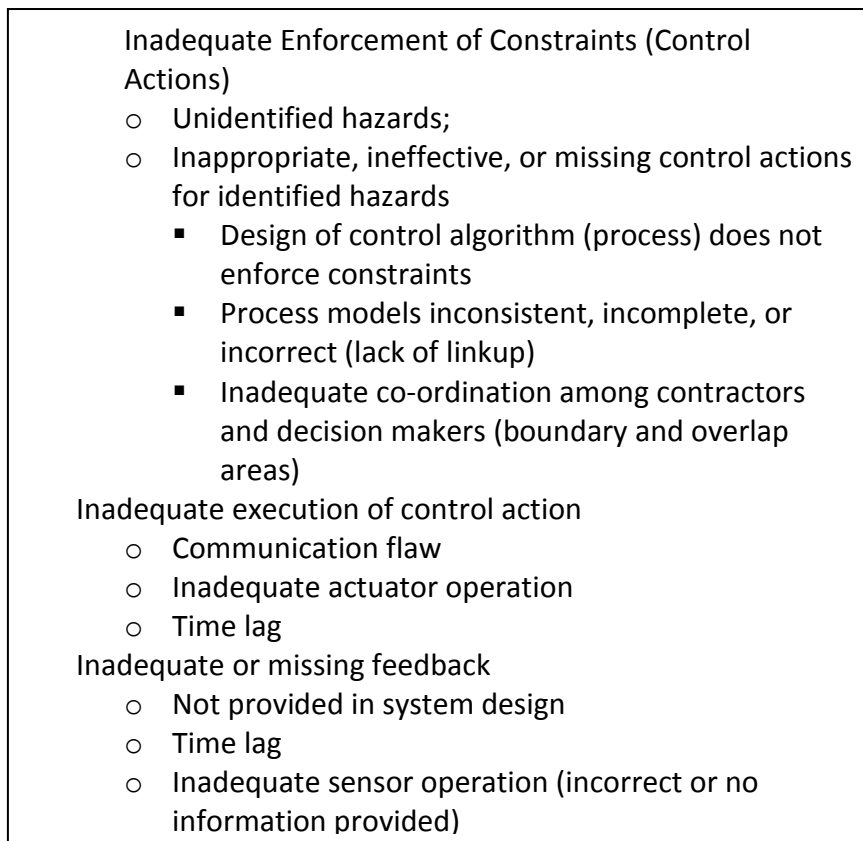


Figure 2.7. Flaw classification (Adapted from Leveson, 2004)

The causes of accidents can be understood in terms of flaws in control loops between components during design, development, and construction operations. These flaws have been classified by Leveson (2004) as shown in Figure 2.7. Each control loop is investigated at every level of the socio-technical control structure and its contribution to inappropriate H&S behaviour evaluated. As a result of this approach attention is not only on the proximate events of accidents but also on the influence of other organizational factors and role players.

#### **2.4.11 Hierarchy of Causal Influences in Construction Accidents Model**

A study was conducted by the University of Loughborough and the University of Manchester Institute of Science and Technology (UMIST) on behalf of the Health and Safety Executive (HSE) in the United Kingdom which employed a combination of a detailed study of 100 construction accidents and focus groups to identify what aspects of H&S was compromised and the reasons for it being compromised (HSE, 2003; Haslam, Hide, Gibb, Gyi, Pavitt, Atkinson and Duff, 2005; Gibb, Haslam, Gyi, Hide and Duff, 2006). The objective of the study was to use the findings to develop an accident causation model to describe the process of

accident causation including the contribution of project, site, management and individual factors in construction industry accidents.

#### 2.4.11.1 Discussion with Focus Groups

The focus groups consisted of the following participants, namely

- Client team;
- Senior managers from generalist and specialist contractor firms;
- Site managers – mix of those in general supervisory and managerial roles and those with health and safety responsibilities;
- Operatives (large site) tradesmen or general operatives;
- Operatives (small site) tradesmen or general operatives;
- Industrial safety professionals and construction enforcement officers; and
- A mixed discipline group (trades and professionals).

The aim of the focus groups was to consult with stakeholders in the construction industry to identify where failures occurred and why accidents still happened under the following themes, namely:

#### 2.4.11.2 Project Concept, Design and Procurement

- Client background (skills and experience of the client);
- Selection of the design team (designers giving consideration to practicalities of construction?);
- Procurement of contractors (what role does price and H&S play in selection?);
- H&S considerations (is H&S in construction considered?);
- Allocation of resources (financial – where the money is spent);
- Legislation (Enhances or hinders?); and
- Strategic design considerations (Choices of site, appropriate building design).

#### 2.4.11.3 Work Organisation and Management

- Project management and supervision (Style, degree of input and instruction from management and supervisors);
- Managing change (Handling of any design modifications of work in progress);
- Work scheduling (Time pressures, overlap of operative / trades);
- Resources (Availability of contractors, suitable skills of contractors);
- H&S considerations (Risk of injury assessed, H&S managed appropriately); and
- Site layout and logistics (Safe access routes, placement of essential services).

#### 2.4.11.4 Task Factors

- Tools and equipment (Appropriate selection, maintenance)
- Adequacy and use of procedures/method statements (Appropriate?)
- Is H&S considered?
- Training in task and H&S skills (Appropriate?);
- Work load / time constraints (Time pressure upon individuals and/or groups);
- Environmental conditions (Weather, out of hours work); and
- Design of task or working area (Layout of immediate area, is H&S and access considered?)

#### 2.4.11.5 Individual Factors

- Experience and competence of all employees;
- H&S considerations (H&S behaviour, attitude to risk);
- Personality influences;
- Health status and fitness for work; and
- Conformity (Company ethos, pressure to comply) (HSE, 2003; Haslam, Hide, Gibb, Gyi, Pavitt, Atkinson and Duff, 2005; Gibb, Haslam, Gyi, Hide and Duff, 2006).



The main issues that emerged were, namely:

- Clients and designers gave insufficient consideration to H&S despite their legal obligations to do so;
- Competitive pricing among contractors gave an advantage to companies less diligent with H&S;
- Key documentation, such as the H&S plan, method statements and risk assessments were treated as paper exercises, having little practical benefit;
- Lengthy sub-contractor chains resulted in elements of the construction team being distanced from responsibility, inadequately supervised, and with low commitment to projects;
- Frequent revision of work schedules that led to problems with project management and undesirable time pressure;
- A 'long hour's culture' in the industry resulted in fatigue, compromised decision-making, productivity and H&S;
- Bonus payments acted as strong incentives, but encouraged productivity over H&S;
- A skills shortage in the industry was leading to increased reliance on inexperienced workers, coupled with difficulties verifying competency;
- Problems existed with the availability, performance and comfort of PPE; and
- Training was seen as a solution to all problems, but with content often superficial (HSE, 2003; Haslam, Hide, Gibb, Gyi, Pavitt, Atkinson and Duff, 2005, Gibb, Haslam, Gyi, Hide and Duff, 2006).

There have been improvements in H&S culture over recent years, but H&S still have to compete with other priorities such as the outdated Iron Triangle of time, cost and quality.

## 2.5 Analysis of Construction Accidents

The study of construction accidents conducted by Haslam *et. al.* (2006) included a sample of 100 construction accidents that were studied to uncover additional evidence on the problems that the focus groups raised.

The research findings were, namely

- Over two-thirds (70%) of accidents caused were due to problems associated with workers or work terms and more specifically their actions, behaviour and capabilities. This indicated inadequate training, education and supervision.
- High levels of background noise and physical distance between work teams contributed to poor communication within work teams which resulted in accidents;
- In many cases, workers who were moving around the site, for example, and not specifically performing the task caused accidents to occur;
- Half (49%) of accidents were caused by inefficiencies of factors of the workplace, most notably was poor housekeeping, space availability and problems with the site.
- Although weather conditions incur much of the blame for the poor state of the construction H&S record, this research found little evidence in support of this phenomenon;
- Equipment flaws, including PPE, accounted for over half (56%) of the incidents. This was due to the misuse of equipment, whereby the inappropriate equipment was utilized to carry out tasks, this included equipment with poor design. These problems arose from suppliers, designers and purchasers not paying sufficient attention to the H&S of users.
- Insufficiencies with the appropriateness and general state of materials, as well as the packaging, was responsible for the cause of more than a quarter (27%) of incidents;
- Originating influences, particularly shortfalls with risk management, existed in almost all the cases looked at (94%);
- Frequently, no risk assessment had been undertaken covering the circumstances that took place in the incident and when an assessment was carried out, they were frequently found to be superficial and predicted to be unlikely to have in any way prevented the accident from having occurred;
- It appears that PPE is relied upon habitually as a substitute for risk elimination or reduction at source;

- It was found that approximately half of the 100 incidents looked at could have been easily mitigated through design change. It has surfaced that despite legal obligations on the designer, an overwhelming amount of said designers still fail to address the H&S implications of their designs and specifications;
- When investigations of the accidents took place by supervising contractors or employers, the investigations were of a superficial nature that did not delve into H&S foresight in terms of prevention. Investigations were generally focused on H&S failures in terms of the activity being undertaken, without capturing the upstream contributing factors involved;
- The contribution from clients on H&S appeared to be partial in the construction sectors that dominated this research, namely major building, residential and civil engineering;
- A significant number of the accidents researched were caused by commonplace hazards and activities that would continue to occur on site whatever design changes might be made (HSE, 2003; Haslam, Hide, Gibb, Gyi, Pavitt, Atkinson and Duff, 2005; Gibb, Haslam, Gyi, Hide and Duff, 2006).

Together, these factors are suggestive of failings in education, training and the prevailing H&S culture displayed within the industry. A significant number of individuals present in construction both on and off site, still persist to only value H&S considerations superficially.

## **2.6 The Accident Model**

The findings of this study informed the development of an accident causation model as shown in Figure 2.8 that clearly illustrated the hierarchy of influences present in construction incidents.

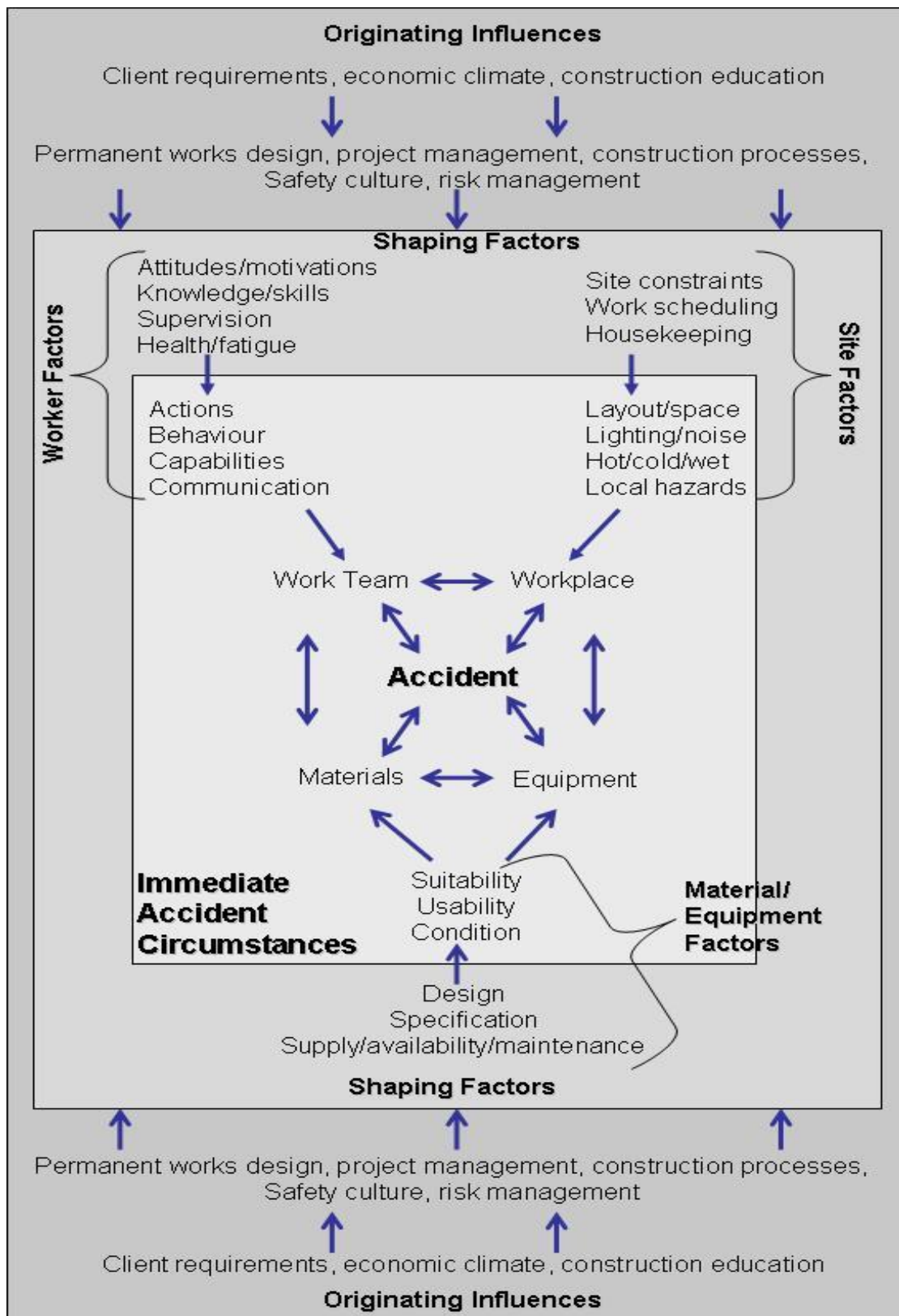


Figure 2.8. Hierarchy of Causal Influences in Construction Accidents (HSE, 2003)

The model shown succeeds in describing how incidents arise from a shortcoming in the interaction amongst the workplace, work team, materials and equipment. These Immediate Accident Circumstances are affected by Shaping Factors whereby the capabilities, behaviour, communication and actions of the work team are affected by their supervision, fatigue, health, motivations, attitudes, skills and knowledge. The workplace is affected by housekeeping, site constraints and work scheduling. The suitability, usability, condition and, therefore safety of materials and equipment depend on their design, specification and supply/availability. These shaping factors are subject to Originating Influences or root causes, including the construction process, project management, H&S culture, client requirements, education provision, risk management, economic climate and permanent works design. To achieve and sustain a meaningful improvement in H&S standards it will require directed efforts to be dispersed amongst all levels in the influence hierarchy.

## **2.7 Other causation models**

The cognitive reliability and error analysis method (CREAM) developed by Hollnagel (1998) allows us to distinguish amongst causes (genotypes) and effects (phenotypes or manifestations) and further allows the description in full context in which errors and accidents occur.

Attribution theory presents itself as the concern with how individuals process information in shaping the causality of events. It pays consideration that danger is always present within the workplace and conceptualizes the role of human action in the controlling of the danger. The model delves into the investigation of contributing factors that affects an individual's behaviourism when presented with danger and it shows how people may, through their actions, create danger and also how they are able to control that danger and prevent harmful outcomes (Katsakiori, Sakellaropoulos and Mantakis, 2009).

## 2.8 Accident investigation methods

It has been argued that the classification of the cause of accidents will determine the accident investigation method to follow (Katsakiori, Sakellaropoulos and Mantakis, 2009). Generally, most risk assessment techniques and accident analysis are based upon the linear notion of causality which have severe limitations in the modelling and analysis of accidents especially in terms of modern complex systems. According to Katsakiori et al. (2009) some of the accident investigation methods include:

- **Fault tree analysis (FTA)** – an accident/incident is picked and all the possible contributing errors that could have led to the incident are diagrammatically represented as a tree in order to show the logical connections and causes leading to a specified incident. Bell Laboratories developed FTA in the 1960s. FTA was developed in the 1960s as an analytical tool for identifying relationships and it remains the most widely used tree techniques. The FTA technique does not aid the investigator in gathering information but rather analyses existing information. The analysis begins with the undesired event which must be specifically defined which is then linked to preceding conditions and events by “AND” and “OR”. The use of FTA allows investigators to see the causal sequence of logical relations – basically how the undesired event was caused;
- **Management oversight and risk tree (MORT)** – MORT was developed in 1973 by W. G. Johnson. It presents itself as a logic trees diagram which contains three foremost branches. The branch that concerns itself with specific oversight and errors which are related to the accident being investigated is known as the S-factors. The branch that is concerned with the awareness of certain risks that for some reason was not controlled is known as the R-factors or assumed risks. The branch that represents general characteristics of the management system that contributed to the accident is known as the M-factors. Each element of the tree is numbered, these numbers correlate to a list of specific questions that the analyst should ask. The tree diagram is analysed by assessing each element and classifying them as either “satisfactory” or “less than adequate” in order to measure adequacy. This method allows the investigator to look for evidence and investigate facts;

- **Multilinear events sequencing (MES)** – Ludwig Benner developed MES in 1975 as a charting technique which shows events on a timeline in chronological order is based on the premise that an accident begins when a stable situation is disturbed. This method differentiates between actions, actors and events to help the analyst establish which are the main actors and their actions so that it can be mapped against events on a flexible timeline. The analyst can use this information to draw up an accident logic chart which sequentially depicts the actors, actions and events;
- **Systematic cause analysis technique (SCAT)** – SCAT was developed in the 1980's by the International Loss Control Institute (ILCI) and is displayed as a chart containing five blocks which corresponds to five stages in the accident causation process and utilizes checklists that contains questions pertaining to each of the respective blocks. This preventative method uses a checklist of questions about personal and job factors and questions relating to a safety management system designed by the ILCI;
- **Causal tree method (CTM)** – CTM is a tree technique that was developed by Leplat in 1978. It starts with the end event (accident) and works backwards noting the variations in the usual process that contributed to the accident. There are four main types of variations: individual, task, equipment and the environment. The variations are displayed in an analytical tree which shows the causal relationships;
- **Occupational Accident Research Unit (OARU)** – OARU was developed by Kjellén and Larsson in 1981. It has two levels of reasoning, namely describing the sequence of the accident that has three phases – initial, concluding and injury phases - and finding the determining factors that can be organizational, social and technical properties of the production system;
- **TRIPOD** – TRIPOD was developed by the University of Leiden and the University of Manchester in the 1990's and follows Reason's accident causation model. It is based on the idea that organizational failures are the main factors in accident causation and an accident occurs when one or more barriers fail. There are 11 general failure types that can cause

barriers to fail. The objective of this method is to produce a profile depicted by a bar graph of the magnitude of the 11 general failures present in an organisation;

- **Accident evolution and barrier function (AEB)** – AEB was developed by Svenson in 1991. It addresses H&S barriers and their functions and operates on the principle that it is conceivable to prevent or intervene the development of the series of any two successive errors, be it human or technical, through barrier functions that are adequate. The aim of this technique is to define accident evolution in the form of a flow diagram which shows human, technical errors and functions related to specific errors;
- **Integrated Safety Investigation Method (ISIM)** – The transportation Safety Board of Canada developed ISIM in 1998. It begins with the collection of data. The data captured is information regarding equipment, personnel, tasks, and environmental conditions, this data is analysed in order to recreate the sequence of events that will help identify underlying factors and unsafe conditions. This allows us to assess the level of risk that may be present in said unsafe condition and examine the status of barriers (physical or administrative). The objective of ISIM is so accident and safety deficiencies are adequately defined, and risk controls are recommended;
- **Norske Statesbaner (NSB)** – In the early 2000's NSB was created by Norske Statesbaner. NSB aims to focus on human, technical and organizational interactions by identifying the series of actions and events whereby barriers were absent or not respected and broken. NSB utilizes a questionnaire, addressing factors such as training, human systems interface, procedures/documentation, tools, equipment, organizational management, local management, work preparation, communication, task completion, and work environment;
- **Work accidents investigation technique (WAIT)** – Aspinwall and Jacinto developed WAIT in 2003. It combines the theoretical approaches of Reason and Hollnagel. This method also involves questionnaires and affords detailed direction for collecting data. It contains two successive phases, starting with a simplified investigation that allows the identification of active failures followed by a second investigation that is an in-depth analysis which allows us to identify the influencing factors associated with the working



environment and the workplace, for each of the identified active failures. It includes the analysis and identification of individual factors and job factors as well as the organisational and management deficiencies;

- **Health and Safety Executive (HSG245)** – HSG245 was developed by Health and Safety Executive (HSE) IN 2004. It provides aid for finding facts with specific structured questions to discover the reasons for why the incident happened and find direct, underlying and root causes;
- **Control change cause analysis (3CA)** – Developed by Kingston in 2007, it is systemic as it covers the management system and views an incident/accident as a series of events in which undesirable deviations occur. When the set of substantial events is established, the investigator can then identify barriers and controls that could have been avoided or their effects reduced. The investigator can then establish and discover the inadequacies of each barrier/control and reason about the processes and management arrangements that allowed the barrier problems to exist at the time of the accident (Katsakiori, Sakellaropoulos and Mantakis, 2009).

The wide range of accident investigation methods suggest that using a standard one-size-fits-all approach to accident investigation is inappropriate without first understanding the applicable theory or model of incident causation. Rather, the accident investigation model should be aligned with the theory or model of accident causation especially considering that accidents potentially progress over a period of time through a combination of numerous small failures, both machine and human (Perrow, 1999). Accident causation models are used as techniques for incident examination to study the causes of the occurrence of an incident.

Conventional approaches to incident investigation have tended to pay more attention on the identification of the presented failures, activities and events that led up to an accident. Human errors have been credited as the main and primary cause of major accidents. This accusation that the failures of frontline individuals are the root cause of accidents serve as a way to provide a smokescreen from the latent conditions that actually contribute to accidents.

A systems method to probing the causes of incidents recognizes the need to comprehend why human errors occur within the operational environment. It also becomes a necessity to identify both the immediate and underlying causation of an accident, in order to recognize effective control measures to prevent a similar accident that may occur again. The systems approach to understanding the causes of accidents allows for the dynamic interactions between several factors at multiple levels. While certain elements may be found to have a substantial effect, it is the combination of the elements that eventually leads to accidents occurring. The system is therefore more than the sum of the factors that are within it. Change in one factor may have an impact on any of the others. Any level of analysis needs to consider all the related aspects in order to optimise the identification of appropriate control measures.

## **2.9 Summary**

This chapter comprehensively reviewed several existing theories on accident causation to identify and understand what experts believe are the causes behind construction accidents. This chapter also aims to determine where the causal factors lay with regards to the effectiveness of the project management lifecycle in preventing an accident from reoccurring. The accident causation theories discussed are as follows:

- Accident Proneness Theory;
- Goals-Freedom-Alertness Theory;
- Adjustment-Stress Theory;
- Distractions Theory;
- Chain of events (Domino and Updated Domino theory);
- Multiple Causation Model;
- Reason's Framework for Accident Causation;
- Constraint-Response Theory;
- Human Error Theories; and
- Systemic accident model

This chapter also discusses the nature of the construction industry, the difference between an accident and an incident and it discusses several accident investigation methods.

## **CHAPTER 3: METHODOLOGY**

### **3.1 Introduction**

This chapter presents the research methodology employed in this study. Research methodology is the general process a researcher uses to carry out a research study (Leedy and Ormrod, 2001). It is systematic in nature and provides the tools and techniques to collect and analyse data in an unbiased manner in order for the researcher to develop conclusions relating to the research problem (Goddard and Melville, 2004).

### **3.2 The Concept of Research**

Research is the careful search or systematic investigation towards increasing the sum of knowledge according to the Chambers English Dictionary. Fellows and Liu (1997), describe research as a “voyage of discovery”. The information discovered through research depends on the techniques used in the searching process, the location, topic being investigated, and the methods used to collect and analyse data (Ibid). However, research studies can also be undertaken to analyse and synthesise existing findings from other research to provide more clarity or a deeper understanding.

### **3.3 Research approaches or strategies**

Research approach has been described by Leedy and Ormrod (2005) as the general approach the researcher takes in carrying out the study. It is concerned with the plan to collect and construct appropriate data for investigating and testing the research hypotheses (Kotari, 2004). The methods used to gather information depend on the type of data and the problem to be researched (Leedy, 1993).

The following describes the different research approaches available, namely:

### **3.3.1 Basic and Applied Research**

Basic, pure or fundamental research as it is commonly known refers to research that is undertaken for the advancement of knowledge and the discovery of theories whereas applied research refers to the development and application of existing knowledge and theories (Palys, 2008).

### **3.3.2 Descriptive and Analytical Research**

Descriptive research can either be qualitative or quantitative and involves fact finding processes which uses instruments of measurement such as a questionnaire and observations of current situations (AECT, 2001). Analytical research is used for the analysis of knowledge and information that already exists in order to make critical evaluations (Kothari, 2004).

### **3.3.3 Quantitative and Qualitative Approaches**

The two most common approaches to research are quantitative and qualitative (Mackey and Gass, 2015).

#### **3.3.3.1 Quantitative Approach**

The quantitative approach is commonly used for complex and detailed studies which looks to study cause and effect. It involves the collection of factual data which is used to analyse relationships between facts and how accurately they match theories (Fellows and Liu, 1997). The quantitative approach is concerned with the extrapolation of data in numeric form from scientific tools and techniques of measurement which includes structured questionnaires (Hughes, 2006). Data produced using this approach is objective as it excludes people's opinions and feelings therefore making it more reliable than qualitative data (Welman, Kruger and Mitchell, 2005). The results obtained can be easily presented in graphs, tables and by other means which can be rigorously analysed.

### 3.3.3.2 Qualitative Approach

Qualitative approach is concerned with behavioural science which involves the subjective assessment of human behaviour, opinions and attitudes (Kothari, 2004). The researcher is able to determine what motivates people to do what they do through the analysis of qualitative data which is collected through comprehensive singular or group interviews or through questionnaires. The gathering of qualitative data is unstructured, flexible and influenced by external or environmental factors and bias (Fellows et al, 1997). Due to the subjectivity of qualitative data many researchers believe that the analysis of qualitative data needs to be validated or explained with the use of quantitative methods (Tuli, 2011).

Amaratunga *et al.*, (2002) describe qualitative data as a source of well- grounded rich description of processes in identifiable local contexts. With qualitative data the researcher can reserve sequential flow, see precisely which events led to which consequences, and derive fruitful explanations. Qualitative data is made up of comprehensive descriptions of situations, events and relations amongst people and things providing depth and details. Such data are contextually embedded, symbolic, reflexive, and cryptic, standing for nothing so much as their readiness or stubbornness to yield to a profound interpretation and response. In addition, the longitudinal aspect of many qualitative studies allows data to be collected over a period of time and permits the researcher time to develop experiential comprehension of the phenomena. Qualitative data surfaces the chance to create an explanation of phenomena, actions, processes and experiences within a holistic context. Therefore, qualitative data will describe things that really happen in context, as the researcher experiences them (Gilmore and Carson, 1996)

### 3.3.3.3 Triangulation

Triangulation is a concept that refers to the combined use of quantitative and qualitative approaches. The term was coined in 1978 by Denzin for the use of multiple methods of data collection with the objective of increasing reliability of a study (De Vos, 2002). Triangulation is commonly used to confirm or validate findings through convergence of different research approaches Chileshe and Watson, 2005).

## **3.4 Research Styles**

### **3.4.1 Ethnographic Studies**

According to Creswell (2001), ethnographic studies aim to understand the culture, beliefs, behaviour and social structure of a particular group. Ethnographic studies differ from case studies as it studies an entire group of people that share something in common (Leedy et al, 2001). In order to develop theories based on a group the researcher has to immerse himself/herself in the group to ensure the groups actual behaviour and beliefs are studied rather than an external view or opinion (Ibid).

### **3.4.2 Action Research**

This style of research requires the researcher to be actively involved in the study. This enables the researcher to give a personal account of the problems identified and be able to provide suggestions and possible solutions (Fellows et al, 1997).

### **3.4.3 Experiments**

Experimental research involves the investigation of the changes that occur due to interventions made to a study group and the consequent measurement of these changes or outcomes (Williams, 2007). Experiments are commonly performed in laboratories to test relationships between variables by keeping all except one variable constant to examine the resultant effect the changes have to the independent variable had on the dependent variable (Fellows et al, 1997). This style of research is well suited for problems with known variables or which a hypothesis can be formulated with adequate confidence (Ibid).

### **3.4.4 Surveys**

Surveys involve the collection of information about a specific topic by obtaining answers to a set of questions regarding a group's opinions, characteristics, feelings, and experiences relating to that topic which are then analysed so conclusions can be drawn (Leedy et al, 1997). The aim of using a questionnaire is to obtain data that is representative of the entire population by only sampling a small portion of that population (Ibid). Social science research commonly utilises surveys to collect data as it is cost effective, timeous and effective (Ibid).

A research methodology is necessary because there is a finite amount of resources available to undertake field work especially if resources are restricted (Fellows et al, 1997). The research method selected must take into consideration the depth and scope required for the study. Questionnaires result in a study being broad and shallow. The use of case studies results in a narrow deep study and interviews result in a study that is in an intermediate position between the two extremes.

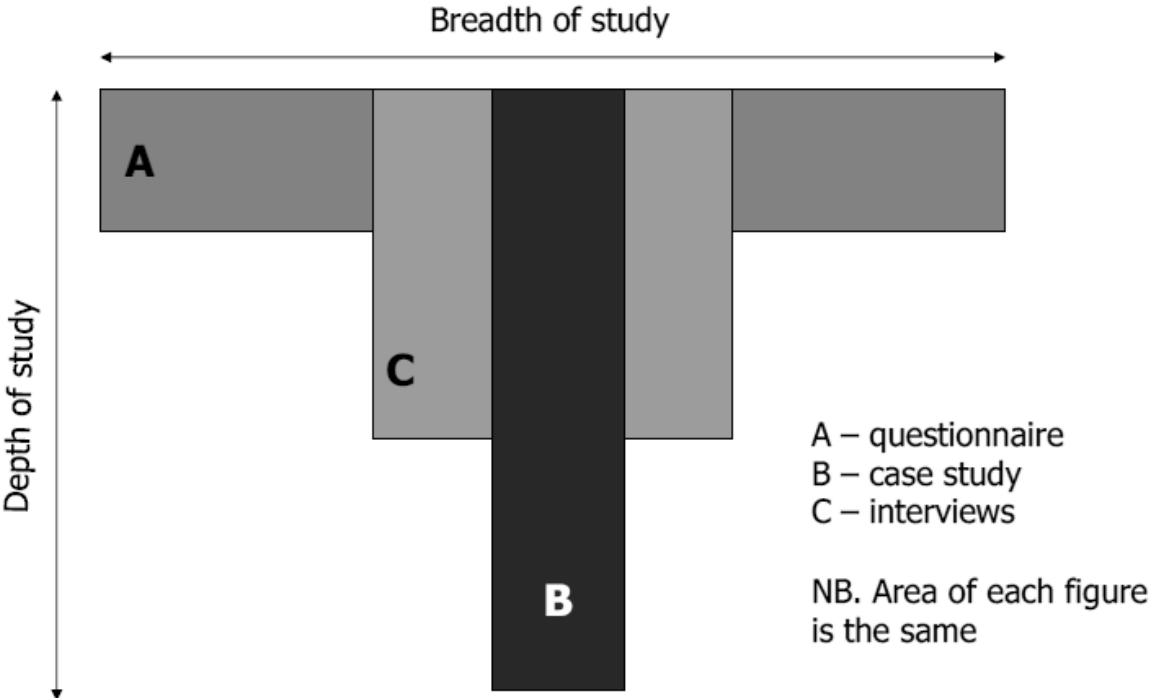


Figure 3. 2 Showing the depth and breadth in question-based studies (Fellows et al, 1997)

3.4.5 Case study approach

Case studies are used to facilitate a comprehensive investigation of occurrences or circumstances related to the research topic (Fellows et al, 1997). According to Yin. (2003), case studies aim to understand and learn more about a situation or problems that are poorly understood. Data can be collected for a case study through observations, records, physical artefacts, interviews and audio-visual material (William, 2007). The case study method of research is used when a contemporary phenomenon such as accident causation is scrutinized against very specific research questions in an effort to surface an association between the phenomenon and the context or real-life situation in which it has occurred. Case studies can be further of use as empirical research into precise scenarios where the boundaries between the

phenomenon and the context are not clearly apparent. According to (Shuttleworth, 2008) the case study method is used to examine a broad scope of research within a single topic available for research. The significance of a case study is that it attempts to highlight a decision or set of decisions with reference to why they were taken, how they were implemented and with what result (Schramm, 1971). Cases could include organizations, processes, events, programs and events (Yin, 2009).

There are five different case studies that may be utilized (Tellis, 1997), namely *exploratory*, *explanatory* and *descriptive*, (Yin, 2003) and *intrinsic*, *instrumental* and *collective* (Stake, 1995):

#### 3.4.5.1 Exploratory

Exploratory methods consist of the assembly of data around a specific research topic, before one forms any theories. The data is utilized in generating an hypotheses and the appropriate research questions. Explanatory methods focus on explaining a course of events typically using a substantial or mature research data pool to answer causal or progression research questions.

#### 3.4.5.2 Descriptive case study

As opposed to the Exploratory method, the Descriptive method is initiated by forming a theory or hypothesis first as to create the framework for data collection. Questions will be derived from the hypothesis.

#### 3.4.5.3 Intrinsic case study

This type of case study focuses on understanding the case itself and not on any theories or abstracts. Intrinsic methods utilizes single or multiple cases to draw specific answers or criteria.

#### 3.4.5.4 Instrumental case study

Instrumental methods focuses on case data to explain other cases or phenomena that was previously documented. It is used to improve or refine ideas and provide insight on a study. The cases are analysed in depth for the purpose of external interest.



#### 3.4.5.5 Collective case study

Collective methods analyse multiple cases to draw themes or patterns from the collective pool of data.

According to these classifications, this study employs the qualitative research approach and utilizes both descriptive and analytical research methods namely both questionnaires and case studies to analyse the problem statement. A combination of explanatory and collective case study approaches were used as causal effects are determined and a course of events was examined from multiple cases. The preferred form of data collection is left to the researcher to decide (Yin, 2003). When a researcher is considering “how” or “why” questions, a contemporary set of events using primary and secondary documents, over which the researcher has little or no control, the case study approach is feasible (Yin, 2009).

### **3.5 Validity and Reliability**

It is a requirement that any research strategy needs to be tested for validity and reliability. This will discover if the approach chosen will measure what we required measured and if the differences in the scores yielded will reflect the true differences of the variable being measured.

#### **3.5.1 Assessing Validity**

Validity refers to the extent in which results are in keeping with the selected research method (Fellows et al, 1997). Validity includes testing for various aspects:

##### 3.5.1.1 Content validity

Content validity warrants sampling suitability with regard to the topics covered by the chosen approach. To achieve content validity, the entire domain of the study should first be defined then the instrument should be assessed to ensure that it accurately represents the domain.

### 3.5.1.2 Face validity

Face validity is concerned with ensuring that the approach appears to be relevant. The first step in the assessment test is generally the face validity test (Gaur and Gaur, 2006). The test is carried out by displaying the test to experts and analysing the responses received. The face validity test does not however display the importance that other aspects of validity show, such as predictive validity, content validity, predictive validity, construct validity, and criterion validity.

### 3.5.1.3 Predictive validity and Criterion validity

Predictive validity means that the measurement should be able to predict other measures of the same aspect. Criterion validity involves validation of data with external or independent criteria being measured.

### 3.5.1.4 Construct validity

Construct validity is often referred to be the most difficult, as it comprises of the determination of the degree to which an instrument successfully measures a theoretical construct (De Vos and Fouché, 2000). It accepted as one of the more commonly used techniques and is defined in its nature to establish a theoretical relationship and examine empirical relationships. Construct validity attempts to create an agreement amongst the measuring instrument and theoretical concepts by searching for expected patterns of relationships among variables (Gaur and Gaur, 2006).

## **3.5.2 Assessing Reliability**

Reliability can be defined as degree of agreement or consistency between two independently derived sets of data and the degree to which the same or similar results are obtained under similar conditions (de Vos and Fouché, 2000). It is the level of accuracy or precision of a strategy or an approach (Ibid). Reliability of data refers to the measuring instrument or data collection process' ability to replicate numeric results when the study is repeated (Gaur and Gaur, 2006). Measuring instruments can be reliable (repeatable) but not valid. A measuring instrument is valid only when it is capable of measuring what it was supposed to measure. A measuring instrument can be reliable (repeatable) but not valid, it only shows validity if it measures what it actually supposed to measure. Babbie and Mouton (2003) suggested that

reliability can be ensured through the use of research approaches that have already been proven in their reliability. An Australian coroner from RMIT University recently completed a study which used the national database that captured data relating to deaths to analyse the causes of fatal accidents in the construction industry. To identify originating influences, shaping factors and immediate circumstances for each incident, this study employed the systemic incident causation model developed by Loughborough University. A sample of 258 closed cases were identified using pre-determined criteria. Eligibility criteria was applied thereafter which reduced the sample further to 81 cases (Lingard, Cooke, and Gharaie, 2013). This study uses a similar approach but with multiple accident causation theories and models.

Another way to determine the measurement of reliability is by using the test-retest method which engages in measuring the same object twice and correlating the results (Gaur and Gaur, 2006). The measure proves reliable if it can produce the same answer in repeated attempts. In order to determine if the findings of the case study were reliable and in line with what Contractors and Health and Safety Officers actually experience on site, questionnaires were used to obtain these professionals' opinions.

### **3.6 Sampling**

The objective of sampling is to provide a good representation of the population while data collection and the processing and analysis of research components are done (Fellows & Liu, 2003). Sampling refers to the process of gathering individuals or entities from a population in a way that ensures generalization about the subject of interest from the sample to the population. Therefore, all members of the population must have an equal chance of being included in the sample and each sample of particular size has the same probability of being chosen (Welman & Kruger, 2001). Sampling can be conducted randomly or not. Simple Random Sampling, Systematic Sampling, Stratified Sampling, and Cluster Sampling are examples of random selection methods while Purposive and Judgemental sampling are examples of non-random selection methods (Welman & Kruger 2001; Fellows& Liu, 2003). The most critical element of the sampling procedures is the choice of the sample frame which constitutes a representative subset of the population from which the sample is drawn. The sample frame adequately represents the unit of analysis.

The sample design used in this study is based on quota sampling as a sample of any 30 lost time accidents investigation reports were required from the participating large construction company for selection and analysis for this study.

A further sample of 10 Contractors and Health and Safety Officers were surveyed to test if the findings of the case study were in line with what these professionals actually experience on site.

### **3.7 Research Design**

A comprehensive review of construction related accidents was done using the accident database of a large construction company. A sample of 30 selected construction accidents for this study were analysed from both flash reports and detailed corporate investigation reports in terms of the actual causes identified and recorded during their investigation and the remedial action taken. These were then compared with seven previously described theories of causation. The theories were annotated as shown in Table 4.1 for easy reference and comparison during the analysis of the selected cases under Section A. An analysis of the data gathered through the questionnaires and findings were compared under Section B from which conclusions were drawn.

### **3.8 Summary**

This chapter described the research methodology employed in this study. This study utilised a qualitative research approach and a combination of descriptive and analytical research methods namely both questionnaires and case studies to analyse the problem statement. A combination of explanatory and collective case study approaches were used as causal effects are determined and a course of events was examined from multiple cases. The sample design used in this study is based on quota sampling as a sample of any 30 lost time accidents investigation reports were required from the participating large construction company for selection and analysis for this study. A further sample of 10 Contractors and Health and Safety Officers were surveyed to test if the findings of the case study were in line with what these professionals actually experience on site.

## CHAPTER 4: FINDINGS

### SECTION A: Case study findings

This section presents the findings of the analysis of the sample of 30 construction accident reports and comparison with 12 accident causation theories namely:

- A - Accident Proneness Theory;
- B - Goals-Freedom-Alertness Theory;
- C - Adjustment Stress Theory;
- D - Distractions Theory;
- E – Chain of events - (Domino theory) – Heinrich’s Theory;
- F - Chain of events - Bird’s and Loftus’ Updated Domino Theory; and
- G - Multiple Causation Model;
- H - Reason’s Framework for accident causation;
- I - Constraints – Response Theory;
- J - Human Error Theory;
- K - Hierarchy of Causal influences in Construction Accident Model;
- L - Systemic accident model

Copies of the actual investigation reports could not be included in the dissertation because of their highly confidential nature. However, the findings have been aggregated and presented in summary form. To protect the identity of persons injured and involved in the investigation all references to them have been removed from the accident descriptions.

A sample of 30 accident investigation reports were analysed by categorising every cause identified in these reports according to the relevant accident causation theories as broken down in Table 4.1 to determine which theories most prevalently or most frequently would have identified the causes as shown in the construction company’s accident investigation reports. The frequency of each accident causation theory was analysed to determine if the identified causes of the accidents were focused on the actions and failures of workers or management and if the remedial actions taken were correct and were able to prevent the accident from reoccurring according to the theories they were classified under.

The causes of the 30 construction accidents as stated in the respective accident investigation reports were classified into three categories namely: *Direct Causes*, *Contributory Causes* and *Root Causes* to determine if the root causes were in fact identified. If the causes identified were the root causes and not direct or contributory causes, then the underlying issues would have been identified and the correct remedial action would have been taken which would prevent the reoccurrence of the accident. If direct or contributory causes were only identified for an accident, then it will be likely that the remedial action taken would have been ineffective and the accident will be likely to reoccur.

Table 4.1. System of referencing Theories and Models of Accident Causation

<b>Theory/Model</b>	<b>Focus of accident causation and target of corrective action</b>	<b>Ref</b>
Accident Proneness Theory	On Worker	<b>A</b>
Goals-Freedom-Alertness Theory	On Worker	<b>B</b>
Adjustment Stress Theory	On Worker	<b>C</b>
Distractions Theory	On Worker	<b>D</b>
Chain of events - (Domino theory) – Heinrich’s Theory	Social & Family Background	<b>E1</b>
	Personal Factors (greed, stupidity, recklessness could be in a person’s nature or learned, etc.	<b>E2</b>
	Unsafe Acts (on the worker); Unsafe Conditions (mechanical or physical hazards)	<b>E3</b>
Chain of events - Bird’s and Loftus’ Updated Domino Theory	<b>Immediate Causes:</b> Unsafe Acts (on the worker); Conditions (mechanical or physical hazards); or Errors	<b>F1</b>
	<b>Basic (contributing) Causes:</b> Personal Factors (fatigue, lack of motivation, insufficient safety knowledge), or Job Factors (unrealistic work schedules, inadequate resources, etc.).	<b>F2</b>
	<b>Lack of Control by Management Root causes</b>	<b>F3</b>
Multiple Causation Model	<b>Management System (Root Causes):</b> Management Policies, Procedures, Supervision, Effectiveness, Training, etc.	<b>G</b>
Reason’s Framework for Accident Causation	<b>Active Failures:</b> On Worker	<b>H1</b>
	<b>Latent Failures:</b> Head Office and Site Management Levels	<b>H2</b>
Constraint-Response Theory	<b>Proximal Factors:</b> Site Management and on Injured Worker Levels	<b>I1</b>
	<b>Distal Factors:</b> Management Level and Includes Project Conception Restraints; Project Design and Project Management Constraints;	<b>I2</b>
Human Error Theories	<b>Behaviour Based Models:</b> On Worker	<b>J1</b>
	<b>Human Factor Models:</b> On Worker; and Design of Tasks, Tools, and Workplaces	<b>J2</b>

Table 4.1 continued...

Theory/Model	Focus of accident causation and target of corrective action		Ref
Hierarchy of Causal Influences in Construction Accidents Model	Immediate Accident Circumstances:	<b>Work Team:</b> Actions, Behaviour, Capabilities and Communication	K1
		<b>The Workplace:</b> Layout/Space, Lighting/Noise, Hot/Cold/Wet, Local Hazards	K2
		<b>Materials and Equipment:</b> Suitability, Usability, Condition	K3
	Shaping Factors:	<b>Work Team:</b> Attitudes, Motivations, Knowledge, Skills, Supervision, Health and Fatigue	K4
		<b>The Workplace:</b> Site Constraints, Work Scheduling and Housekeeping	K5
		<b>Materials and Equipment:</b> Design, Specification and Supply/Availability	K6
	<b>Originating Influences (Root Causes):</b> Permanent Works Design, Project Management, Construction Processes, Safety Culture, Risk Management, Client Requirements, Economic Climate and Education Provision		K7
Systemic accident Model	<b>Direct Level - Human and Technical Systems:</b> Competence, Motivation/Morale, Team Working, Situational Awareness/Risk Perception, Fatigue/Alertness, Health, Communications, Information/Advice, Compliance, Availability of Suitable Human Resources, Inspection and Maintenance, Equipment Operability, Workplace Environment, and External Conditions		L1
	<b>Organisational Level - Organisational and Management Systems:</b> Recruitment and Selection, Training, Procedures, Planning, Incident Management and Feedback, Management/Supervision, Communications, Safety Culture, Equipment Purchasing, Inspection and Maintenance, Design, and Pay and Conditions		L2
	<b>Policy Level - Corporate Policy Influences:</b> Contracting Strategy, Ownership and Control, Company Culture, Organisation Structure, Safety Management, Labour Relations, Profitability		L3
	<b>Environmental Level - Social, Political and Market Context:</b> Political Influence, Regulatory Influence, Market Influence, Societal Influence		L4

Table 4.2: Correlation of construction accidents causes against accident causation theories

Case	Causes identified	Accident Prone Theory	Goals-Freedom-Alertness Theory	Adjustment Stress Theory	Distractions Theory	Domino theory			Updated Domino Theory			Multiple Causation Model	Reason's Framework for Accident Causation	Constraint-Response Theory		Human Error Theories		Hierarchy of Causal Influences in Construction Accidents Model							System of influences approach model				
		A	B	C	D	E1	E2	E3	F1	F2	F3	G	H1	H2	I1	I2	J1	J2	K1	K2	K3	K4	K5	K6	K7	L1	L2	L3	
1	On the 17th May 2016 the front end loader (FEL) operator transported a drum of primer inside the load bin to the work area approximately 1.5km up the road. The operator drove within the closure until he approached one of the teams busy with patching work. Since there was no room within the closure he had to pass the team on the traffic lane. The flagman was stationed with his back to the operator to warn approaching traffic of work in progress. The operator however failed to obtain eye contact with the flagman and proceeded onto the traffic lane. He then noticed a grey Hyundai Atos approaching at high speed. He stopped but before he could reverse the Hyundai collided with the edge of the FEL load bin and ricocheted off the road. Before impact the Hyundai applied brakes and skidded for approximately 20m before it impacted the FEL and another 20m post impact. It came to rest next to the road.No injuries was sustained																												
	•No flagman to control plant although identified in DSTI								1						1				1										
	•Operator failed to comply with requirements	1	1	1	1				1				1					1			1						1		
	•Appointed 8.8's inadequately fulfilling supervisory task.											1									1						1	1	
	•Insufficient communications between Supervisors/Foreman																		1								1		
•Speeding public	1	1	1	1				1				1					1			1						1			
	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1</b>	<b>0</b>		
2	On the 19th of October 2015 at approximately 14h10, a medical treatment injury occurred when the IP, an electrician from Electron was tightening up a bolt using a G-clamp and his hand slipped. This in turn causing the IP to hit his right elbow against as/steel plate (situated directly behind him) and sustaining a laceration. He was taken to the site container for first aid treatment and then taken to hospital where further medical attention was given. He resumed his normal duties the following morning.																												
	• Inadequate assessment of hazards and risks.	1	1	1	1			1																			1		
	• Failure to use PPE (Overalls / long sleeves).	1	1	1	1			1																		1			
	• Sharp edges not covered and protected.	1	1	1	1			1																		1			
	• Congestion or restricted movement.	1	1	1	1													1											
	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>		
3	On the 24th of August 2015 at approximately 13h30 a VW golf wanted to overtake a Toyota Avenza within the closure, on a bent in the road. The driver of the VW saw the employees working in the closure and swerved back into the traffic lane unfortunately clipping the Avenza on the back resulting in the driver losing control which led to the Avenza overturning straight into the closure were our team was busy pouring concrete. Luckily none of our employees was injured. 7 occupants in the Avenza. 3 males and 3 females and 1 little girl. 1 male sustained severe head wound and fractured leg at least as he was flung approximately 8m from the vehicle. 1 female sustained serious head wound that could be seen. Other two internal injuries. Luckily the little girl was unharmed but shaken as expected																												
	• Speeding in closure	1	1	1	1			1				1					1			1						1			
	• Illegal overtaking	1	1	1	1			1				1					1			1					1				
		<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	
4	On the 27/10/2015 at 14h00 the IP was instructed to mix mortar to seal the shutters before the concrete pour. After he mixed the mortar and located it to the work area he went to drink some water and then climbed onto the scaffolding. As he descended, via a scaffold ladder, to the required level (approximately 2m) he slipped on one of the steps. As he slipped his hands moved upwards resulting in the ladder unhooking at the top. This ultimately resulted in him falling backwards onto some tie rods. He was moved by the supervisor and colleagues to the platform above and extracted by medical basket with the tower crane. Due to the possible severity he was airlifted to Milpark. Days lost coincided with pay weekend and as such no physical shift was lost. The IP was released over the weekend and reported to work on the 2nd on light duty for 3 weeks.																												
	• Scaffold was unsafe and did not comply with SANS 10085	1	1	1	1			1				1					1			1						1			
	• Ladder used was a split ladder only tied down at the bottom	1	1	1	1			1				1					1			1						1			
	• Scaffold ladder was on the outside of the scaffolding	1	1	1	1			1				1					1			1						1			
	• Supervisor, Scaffold inspector as well as IP was trained in scaffold erecting however failed to identify the hazard								1												1					1			
	• Safety harness was not used – General practice	1	1	1	1			1	1			1					1			1	1					1			
• Scaffold was inspected that morning and signed off.											1									1						1			
	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>1</b>	<b>0</b>		
5	On the 6th February 2017 the IP was performing setting out on the atrium wall at the ground floor level. She was busy installing the fish line that was removed at the atrium wall to check the angles as she has to remove the DPC plastic covering the floor looking for the floor pins to tie the fish line. The raking atrium wall fell on top of her sustaining a multiple lumbar transverse process fractures.																												
	• Brick force was not included in the wall	1	1	1	1		1	1				1					1		1							1			
	• Propping of the wall not secured properly	1	1	1	1		1	1				1					1		1							1			
	• Failure to determine a hazardous situation.	1	1	1	1		1	1				1					1		1							1			
	• Lack of supervision											1										1					1		
	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1</b>	<b>0</b>		





Table 4.2 continued...

Case	Causes identified	Accident Proneness Theory	Goals-Freedom-Alertness Theory	Adjustment Stress Theory	Distractions Theory	Domino theory			Updated Domino Theory			Multiple Causation Model	Reason's Framework for Accident Causation	Constraint-Response Theory		Human Error Theories		Hierarchy of Causal Influences in Construction Accidents Model							System of influences approach model			
		A	B	C	D	E1	E2	E3	F1	F2	F3	G	H1	H2	I1	I2	J1	J2	K1	K2	K3	K4	K5	K6	K7	L1	L2	L3
		<p>The Injured was skinning a cable using a cable knife when the knife slipped and accidentally cut his left finger. The injured sustained a minor cut on the left index finger</p>																										
12	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Employee did not wear correct PPE - gloves	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
		3	3	3	3	0	3	0	3	0	0	0	3	0	0	0	3	0	3	0	0	0	0	0	0	0	3	0
<p>The Injured was chopping tiles off a wall using a hammer and chisel in a toilet at Level 5 – Portion 24. Whilst chopping the tiles one of the tiles pulled loose from the wall surface and fell. As the tile fell the employee reacted by putting his knee in the way of the tile to prevent it from falling to the ground and breaking which resulted in him sustaining lacerations to his left knee area.</p>																												
13	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
		2	2	2	2	0	2	0	2	0	0	0	2	0	0	0	2	0	2	0	0	0	0	0	0	0	2	0
<p>The injured was walking on site after collecting tools from the stores when he tripped over the mesh wire and fell, sustaining a contusion to his hand. The injured was taken to hospital to make sure that he did not fracture anything and was eventually treated for a contusion to his hand. He returned to work the next morning.</p>																												
14	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• Employee did not wear correct PPE - Hardhat	1	1	1	1		1		1				1				1		1							1		
	• Daily hazard inspection was not done												1									1					1	
		3	3	3	3	0	3	0	3	0	0	1	3	0	0	0	3	0	3	0	0	1	0	0	0	0	3	1
<p>On the afternoon of 05 April 2017 at approximately 15H00, the IP and a colleague were busy with waterproofing at the bottom of Core 3 Lift shaft. Directly above them a protective board “canopy” was installed to prevent any falling objects or concrete debris from above and injuring them. As they were progressing with their task, a section of Channel Iron approx. 800mm long and 3mm thick came crashing through the protective canopy causing a large section of the canopy to collapse onto the IP below. The IP’s colleague managed to escape the collapsed section of canopy without any harm. The Safety Officer and other employees assisted the IP out from under the collapsed canopy. The IP was immediately given First Aid Treatment and taken to Umhlanga Hospital for further assessment. It is suspected that the channel iron fell from a higher level where other contractors were busy installing structural steel.</p>																												
15	• Protective canopy was not strong enough																									1		
	• The DSTI was not properly conducted.											1														1		1
	• The area was not safe for the employees to work.										1						1		1						1			
		0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	2	0	1	1	0	0	0	2	1
<p>The injured was walking on an unfinished decking where he was working, holding a breaker and an extension cord taking them to the store room. While walking he stepped on a coffer and his left leg slipped through the reinforcing and got scratched by the sharp ends of the rebar.</p>																												
16	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The DSTI was not properly conducted.											1													1			1
		2	2	2	2	0	2	0	2	0	0	1	2	0	0	0	2	0	2	0	0	1	0	0	0	0	2	1
<p>The injured employee was installing cable troughs from a cherry picker and the troughs were not at the desired level. He then lowered the cherry picker in order to start aligning the troughs to the right level. He placed his left hand on top of the cherry picker rail while he operated the cherry picker with his right hand. As the cherry picker went down, his left finger got pinched between a trough that was already installed and the cherry picker.</p>																												
17	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The DSTI was not properly conducted.											1													1			1
	• Lack of training	1	1	1	1	1					1		1												1			1
	• Inexperienced employee worked independantly on plant	1	1	1	1		1		1				1				1		1							1		
	4	4	4	4	1	3	0	3	1	0	2	3	0	0	0	3	0	3	0	0	2	0	0	0	0	4	1	0

Table 4.2 continued...

Case	Causes identified	Accident Proneness Theory	Goals-Freedom-Alertness Theory	Adjustment Stress Theory	Distractions Theory	Domino theory			Updated Domino Theory			Multiple Causation Model	Reason's Framework for Accident Causation		Constraint-Response Theory		Human Error Theories		Hierarchy of Causal Influences In Construction Accidents Model							System of influences approach model		
		A	B	C	D	E1	E2	E3	F1	F2	F3	G	H1	H2	I1	I2	J1	J2	K1	K2	K3	K4	K5	K6	K7	L1	L2	L3
18	The Injured was assisting a fellow employee to start the generator. The employee was using an incorrect start rope and the generator did not have a starter cover. The fellow employee started the machine and when the rotor started to rotate, the start rope which had a handle on was whipped by the rotor and struck the injured on his face. The injured sustained swelling and lacerations around both eye lids. The handle of the start rope could not be found at the scene of the incident.																											
	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The DSTI was not properly conducted.											1									1						1	
	• Lack of training	1	1	1	1	1					1		1								1					1		
• Generator checklists and inspections were not done											1									1						1		
		3	3	3	3	1	2	0	2	1	0	3	2	0	0	0	2	0	2	0	0	3	0	0	0	3	2	0
19	The IP was working on level 3 installing blinder plates; The blinder plates get installed on top of the doors whereby the installer stand on a step ladder. The IP was measuring the blinder plate when it slipped out of his left hand and cut him on his right hand thumb. The SHE Officer performed first aid on his wound to stop the bleeding and inspected the severity. The ambulance was summoned to site due to the severity of the wound and the IP was taken to Morningside Medic Clinic where he was given eleven stitches on his right hand thumb. X-Ray showed no injury to the bone.																											
	• Employee was negligent.	1	1	1	1		1		1				1				1		1							1		
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The DSTI was not properly conducted.	1	1	1	1		1		1				1				1		1							1		
	• Lack of training	1	1	1	1	1					1		1									1				1		
		4	4	4	4	1	3	0	3	1	0	1	3	0	0	0	3	0	3	0	0	1	0	0	0	4	0	0
20	On the 13th of December 2016 at around 09H00 at level 10 an employee of an appointed subcontractor was instructed to unhook the tower scaffolding that was being hoisted by a tower crane with a four legged chain sling. He started to unhook the chains in sequence, when he was about to unhook the last chain (the fourth one) the three loose chains moved rapidly towards him. The IP then lose balance and went through the opening and fall on to the slab. The IP was then taken to Morning side Mediclinic, where he was declared to have sustained severe head wounds, contusion, pneumothorax and fracture of the scapula.																											
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The employee failed to utilise issued fall arrest equipment.	1	1	1	1		1		1				1				1		1							1		
	• The employee did not have experience in the task.	1	1	1	1		1		1				1				1		1							1		
	• The employee lacked training on the task that he was performing.	1	1	1	1	1					1		1								1					1		
• The employee failed to follow safe work procedure for working at heights.	1	1	1	1		1		1				1				1		1							1			
		5	5	5	5	1	4	0	4	1	0	1	4	0	0	0	4	0	4	0	0	1	0	0	0	5	0	0
21	The IP was installing wooden panels at the Atrium. After discharging a nail into a panel the recoil/repercussion movement of the gun caused the IP to move back and knock his elbow against the scaffolding, the IP instinctively moved forward and knocked the safety mechanism of the gun against his left hand middle finger, because he still had his finger on the trigger the nail gun discharged causing the nail to enter the flesh of his middle finger and exit from the flesh of his ring finger, luckily missing the bone in both fingers.																											
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1							1		
	• The area was not safe for the employees to work.								1								1		1			1				1		
	• The DSTI was not properly conducted.	1	1	1	1		1		1				1				1		1							1		
	• Lack of judgement, after discharging the gun the IP did not release the trigger of the nail gun.	1	1	1	1		1		1				1				1		1							1		
		3	3	3	3	0	3	1	3	0	0	0	3	0	0	0	3	1	3	1	0	0	1	0	0	4	0	0
22	The incident occurred in a mechanical riser shaft at Ground floor at about 13H55. Two employees were instructed to install gas pipes within the mechanical riser shaft. Two other employees were instructed to break defect wall at second floor, about 12 metres from ground floor. While in the process of breaking the wall a half broken stock brick went through an opening leading to the mechanical riser shaft and struck one of the employees working on the gas pipes on the head. The IP sustained a sprain cervical spine.																											
	• The supervisor responsible for the second floor failed to identify possible risk											1									1					1		
	• Two activities happened at the same time on the same area, failure to communicate amongst each other	1	1	1	1		1		1				1				1		1							1		
	• He failed to put a warning sign or to barricade the area	1	1	1	1		1		1				1				1		1							1		
	• The DSTI does not indicate working above or overhead work	1	1	1	1		1		1				1				1		1							1		
		3	3	3	3	0	3	0	3	0	0	1	3	0	0	0	3	0	3	0	0	1	0	0	0	3	1	0

Table 4.2 continued...

Case	Causes identified	Accident Proneness Theory	Goals-Freedom-Alertness Theory	Adjustment Stress Theory	Distractions Theory	Domino theory			Updated Domino Theory			Multiple Causation Model	Reason's Framework for Accident Causation	Constraint-Response Theory		Human Error Theories		Hierarchy of Causal Influences in Construction Accidents Model							System of influences approach model			
		A	B	C	D	E1	E2	E3	F1	F2	F3	G	H1	H2	I1	I2	J1	J2	K1	K2	K3	K4	K5	K6	K7	L1	L2	L3
23	The IP was removing wedges that were securing the glass balustrade of the stair case at 2nd floor of Zone 1, while leaning by the glass balustrading removing the outer wedges using a hammer, he missed the wedge and accidentally hit the corner of the glass where it cracked and broke. He then fell at approximately 7m height to the ground level.																											
	• Supervisor not adequately accessing the task for possible risk and hazards											1										1						1
	• IP gained access to site illegally without following due processes.	1	1	1	1		1		1				1				1		1									1
	• Not adhering to safe work procedure, by leaning on the glass while removing the wedges.	1	1	1	1		1		1				1				1		1									1
	• No adequate working platform provided for the task.	1	1	1	1		1		1				1				1		1									1
	• Lack of judgment by overlooking the risk associated with the task he was performing.	1	1	1	1		1		1				1				1		1									1
• Incorrect tool (Hammer) for the job.	1	1	1	1		1		1				1				1		1									1	
	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>1</b>	<b>0</b>
24	The incident occurred at basement No 6, The IP and his colleague appointed Subcontractor were manoeuvring compressor on the deck to position it so that they will be able to finalise cleaning on the deck. While in the process they decided to lift it at front because it got jammed in some way, the compressor then slanted backwards rapidly causing the backside of the compressor to land on the deck with massive impact. As a result, the main bearer that was used to support the deck broke and causing the compressor and the two employees to fall to the lower level. Employees were taken to Sunninghill Netcare Hospital for observation and were discharged the following day.																											
	• The supervisor responsible for the area was not aware of the activities.											1										1						1
	• Two employees were not authorised to use the compressor.	1	1	1	1		1		1				1				1		1									1
	• The DSTI does not indicate cleaning of the deck with a compressor and the task for moving the compressor was not discussed.																											
• Both employees failed to foresee the hazards associated with the task that they were doing.	1	1	1	1		1		1				1				1		1									1	
	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>1</b>	<b>0</b>
25	On the 4th of September 2016 at a approximately 11:30 am, two employees were in the process of dismantling formwork on the 4th floor towards the slab edge. The two employees were busy removing decking boards and a nail in the board dragged one of the secondary beams which slipped and fell from a height of +- 19 meters to the ground next to the entrance of the parking mall.																											
	• Employee was negligent.	1	1	1	1		1		1				1				1		1									1
	• Lack of hazards awareness	1	1	1	1		1		1				1				1		1									1
	• The DSTI was not properly conducted.	1	1	1	1		1		1				1				1		1									1
	• Lack of training	1	1	1	1	1					1		1									1						1
	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>
26	On the 18 September 2016 the Mechanics Workshop Supervisor, the IP, was attempting to assemble the pivot on the left front hub of the MANITOU. During The process the IP was waiting for his assistant to arrive to bring grease to lubricate the pin prior to installing the required Mechanical parts. The IP had his left hand on the hub while looking over his shoulder to see where his assistant was. During this process the IP was unable to prevent the hub from slipping and lost grip this is when the hub slipped and caught his index finger between the hub and left side of the front axle, This caused the left hand index-finger tip becoming trapped and subsequently the flesh tip sliced off from the nail section.. Employee was rushed to local CMC clinic where attending emergency room practitioner's attended to the IP, where he was treated and bandaged.																											
	• Failure to secure pivot with correct tool,	1	1	1	1		1		1				1				1		1									1
	• Not enough assistants used to assist with activity	1	1	1	1		1		1				1				1		1									1
	• Rushing the job	1	1	1	1		1		1				1				1		1									1
	• Failure to recognise a Hazardous situation	1	1	1	1		1		1				1				1		1									1
	• The Grease required should have been at the vicinity of the task activity location and not in cupboard	1	1	1	1		1		1				1				1		1									1
	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>5</b>	<b>0</b>	<b>0</b>

Table 4.2 continued...

Case	Causes identified	Accident Prone Theory	Goals-Freedom-Alertness Theory	Adjustment Stress Theory	Distractions Theory	Domino theory			Updated Domino Theory			Multiple Causation Model	Reason's Framework for Accident Causation	Constraint-Response Theory	Human Error Theories		Hierarchy of Causal Influences in Construction Accidents Model							System of influences approach model					
		A	B	C	D	E1	E2	E3	F1	F2	F3	G	H1	H2	I1	I2	J1	J2	K1	K2	K3	K4	K5	K6	K7	L1	L2	L3	
27	On Tuesday the 18th October 2016 at approximately the IP was busy conducting precast DCP testing on the foundations for approval by the Resident Engineer from the Employers Agent at extension 24 Nellmapius. The IP and team had already completed testing two raft foundations and were on the third raft foundation when it was established that the tester could not give any reading due to the rock formation underground. The Resident Engineer instructed the IP to move the DCP tester to another/ various locations so as to get favourable readings and these repetitive request continued from testing Point 1 to 4 on the third raft foundation. It was at testing Point 4 that the employee sustained the injury as he verbalised that he lost concentration during the operation/task) resulting in his right hand index finger getting caught between the hammer and the bed of the tester. He was hospitalised and underwent an operation for an avulsion injury sustained to his finger. He was discharged on the 20th of October 2016, his prognosis is currently stable and he is back at work as of the 1st of November																												
	•Employee's loss of focus and concentration	1	1	1	1		1		1				1			1		1									1		
	•The Resident Engineers arriving late on site (after 15h00) for inspections and instructing the IP to speed up the process "as it is becoming late."	1	1	1	1		1		1				1			1		1									1		
	•Operating equipment in an improper manner	1	1	1	1		1		1				1			1		1									1		
	• Fatigue of the employee	1	1	1	1		1		1				1			1		1									1		
	<b>4</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>0</b>	
28	On the 21st of January 2015 at around 9h00 in the morning employees were backfilling at manufacturing block ground floor, at the same time outside of the building on the scaffold platform there was an employee lifting a wheelbarrow to the first floor to do housekeeping. The wheelbarrow slipped and fell from 1st floor wall and hit an employee who was back filling at the ground floor. The victim suffered bruises on left shoulder. The supervisor of the area called the site manager and Safety officer to the scene. Statements were taken, area was accessed, and injured employee was taken to safety officer for treatment and he went back to work.																												
	•Wrong use of scaffold platform	1	1	1	1		1		1				1			1		1									1		
	• Incorrect lifting technique	1	1	1	1		1		1				1			1		1									1		
	• Employees negligence	1	1	1	1		1		1				1			1		1									1		
	• Lack of Supervision.											1									1							1	
	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>1</b>	<b>0</b>	
29	The IP was stacking bricks preparing to start building,when he suddenly felt dizzy,went to sit down for his safety and started experiencing seizures.																												
	• Pre-existing medical condition that the principal contractor was not informed about.	1	1	1	1		1		1				1			1		1									1		
	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	
30	At approximately 10:15am crane 2 was lifting a 3Ton post tensioning cable from blue level (-3) to the laydown area, in the process the hoist rope broke, the main hook and the 3 ton post tension cable rack fell to the ground. No injuries occurred																												
	• The inner core of the wire rope was rusted.																		1								1		
	• Main strand on the rope shifted, causing it to form a bird cage behind the top tower of the crane. (blind spot for operator) There was no warning signs or alert to identify hoist rope damage.	1	1	1	1		1		1				1			1		1									1		
	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	
<b>Total occurrence of each theory</b>		<b>83</b>	<b>83</b>	<b>83</b>	<b>83</b>	<b>5</b>	<b>66</b>	<b>7</b>	<b>75</b>	<b>8</b>	<b>0</b>	<b>21</b>	<b>74</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>66</b>	<b>13</b>	<b>68</b>	<b>7</b>	<b>8</b>	<b>23</b>	<b>4</b>	<b>0</b>	<b>3</b>	<b>88</b>	<b>16</b>	<b>0</b>	

## 4.1 Summary of findings

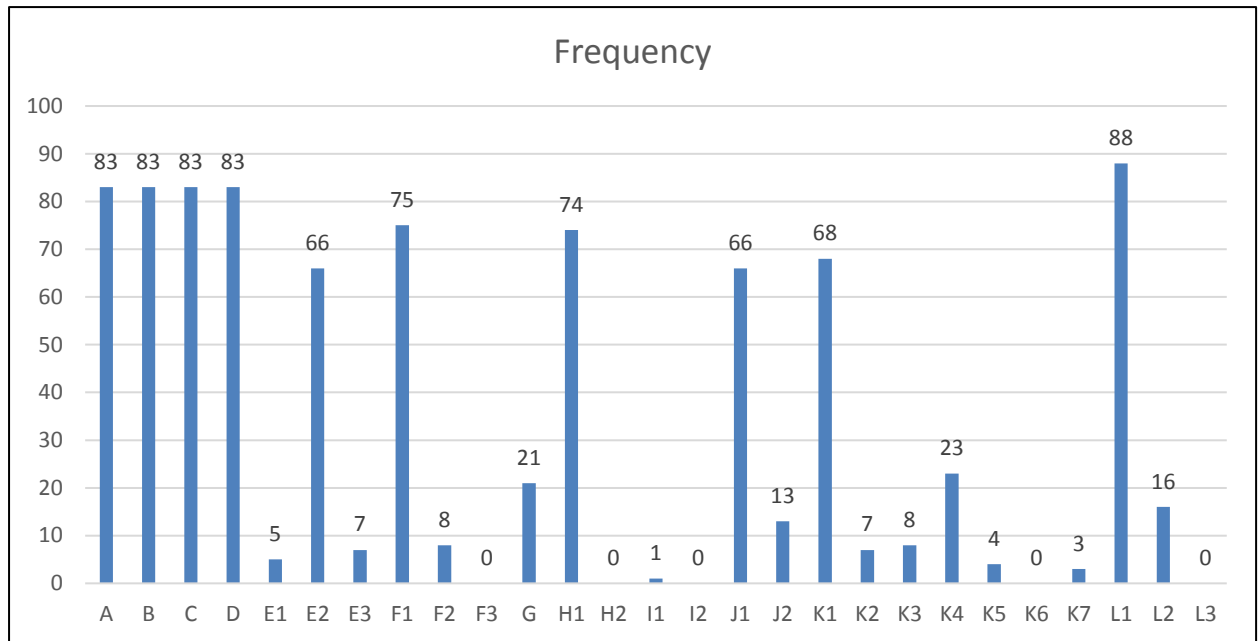


Figure 4.1: Summary of findings

A sample of 30 construction accidents taken from a large South African construction company were analysed in Table 4.2 by categorising the causes of each accident according to the various accident causation theories as broken down in Table 4.1 to determine which theories most prevalently or most frequently would have identified the causes as shown in the company accident investigation reports.

**4.2 Accident causation theories that appeared most frequently**

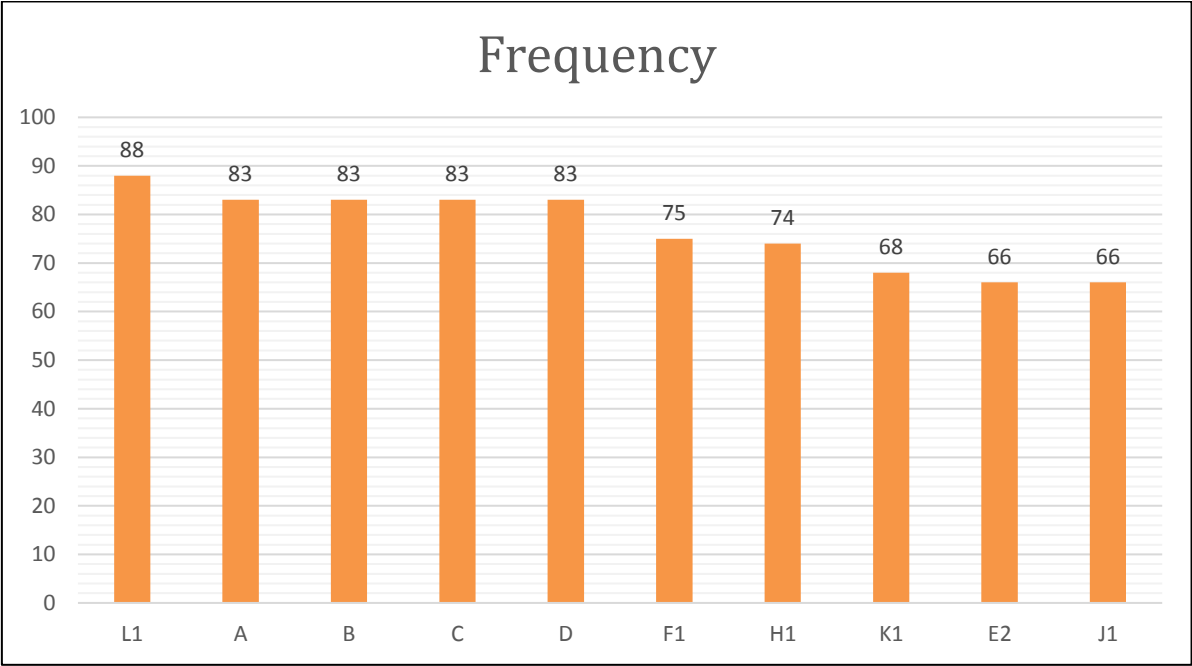


Figure 4.2: Accident causation theories that appeared most frequently

Figure 4.1 illustrates that the causes of the 30 construction accidents when applying the various accident causation theories, models or approaches suggest that workers were negligent since the theories that focused accident causation on workers appeared most frequently namely between a range of 88 and 66.

- L1 - System of Influences Approach model (Frequency:88)
- A - Accident Proneness Theory (Frequency:83)
- B - Goals-Freedom-Alertness Theory (Frequency:83)
- C - Adjustment Stress Theory (Frequency:83)
- D - Distractions Theory (Frequency:83)
- F1 - Updated Domino Theory (Frequency:75)
- H1 - Reason’s Framework for accident causation (Frequency:74)
- K1 - Hierarchy of Causal influences in Construction Accident Model (Frequency:68)
- E2 - Domino theory (Frequency:66)
- J1 - Human Error Theory (Frequency:66)

This finding indicates that if one applied the various theories, models and approaches the causes identified of the 30 construction accidents would typically fault workers as being the root cause of construction accidents in the company.

**4.3 Accident causation theories that appeared least frequently**

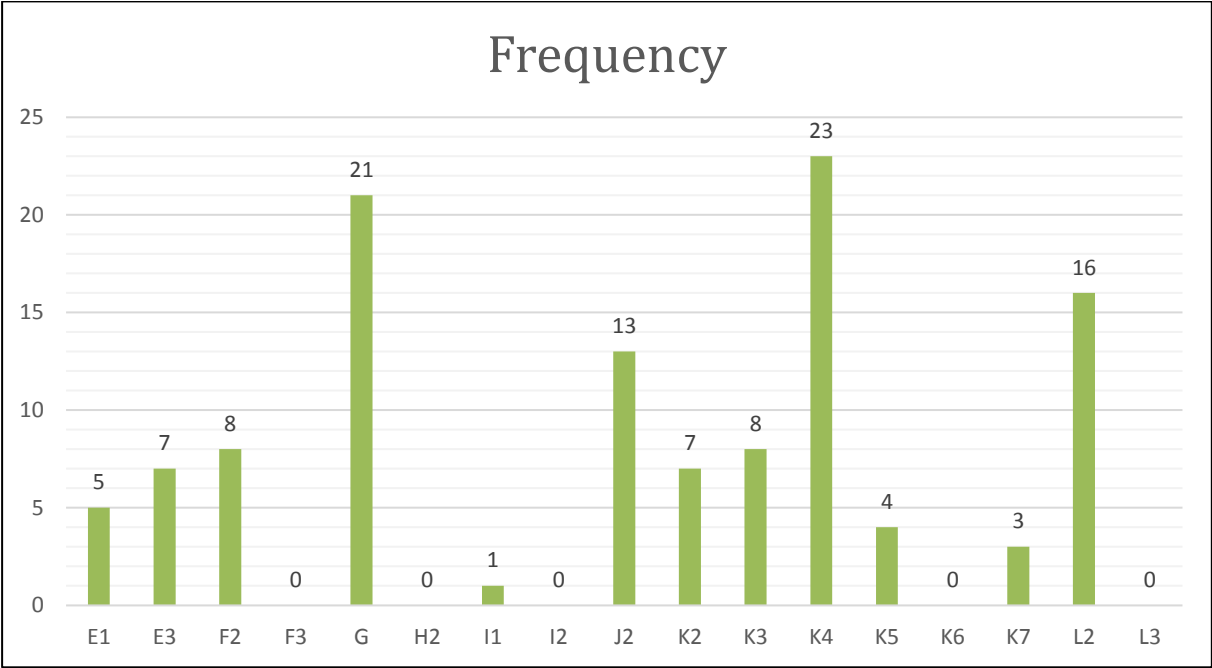


Figure 4.3: Accident causation theories that appeared least frequently

On the other hand, Figure 4.3 illustrates the accident causation theories that appeared least frequently when applied to the 30 selected accident reports. These theories that focus on the negligence or failures of management or the organisation appeared less frequently namely between the range of 0 and 23 because they did not relate to the findings of the accident investigation reports and if applied would have identified different causes that were absent from these reports. These theories were, namely:

- F3 - Updated Domino Theory (Frequency:0)
- G - Multiple Causation Model (Frequency:21)
- H2 - Reason’s Framework for accident causation (Frequency:0)
- I1 - Constraints – Response Theory (Frequency:1)



I2 - Constraints – Response Theory (Frequency:0)

K4 - Hierarchy of Causal influences in Construction Accident Model (Frequency:23)

K7 - Hierarchy of Causal influences in Construction Accident Model (Frequency:3)

L2 - System of Influences Approach model (Frequency:16)

L3 - System of Influences Approach model (Frequency:0)

This finding suggests that existing accident investigation approaches in the company relate to accident causation theories, models or approaches that rarely if not ever relate to the negligence or failures of management or the organisation as being the root cause of construction accidents.

These findings indicate that accident investigation processes are flawed as they predominantly blame the causes of construction accidents on the negligence of workers. As much as worker negligence contributes to the cause of the accident there are further underlying causes such as the lack of training, supervision, health and safety awareness and culture within the organisation, management failing to rotate teams on strenuous tasks and much more that relate to the failure and negligence of management. If these underlying root causes are not addressed the accident will continue to reoccur.

#### 4.4 Total occurrence of each type of cause

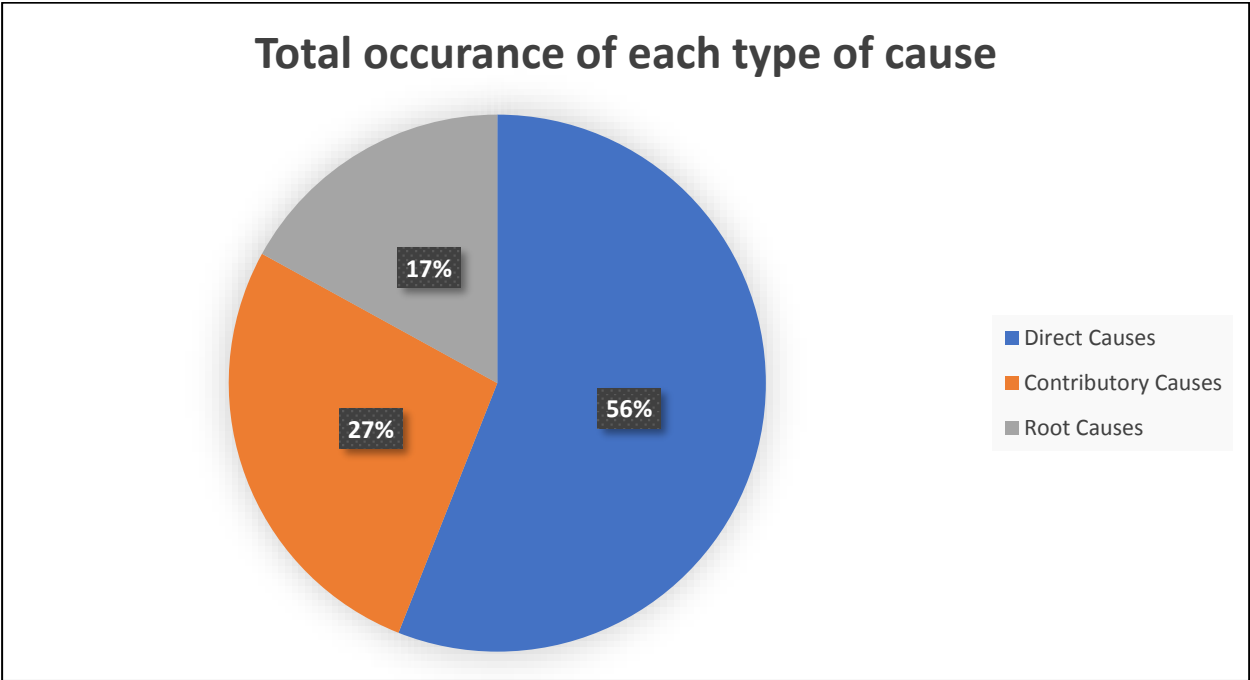


Figure 4.4: Total occurrence of each type of cause

The causes of the 30 construction accidents identified in the respective accident investigation reports were further classified into three categories namely: Direct Causes, Contributory Causes and Root Causes. As Figure 4.4 illustrates, it was found that 56% of causes were direct causes, 27% were contributory causes and only 17% of accident investigation reports identified the root cause of the accident.

This significant finding therefore suggests that of all the investigations done only 17% correctly identified the root causes of the accidents and applied the correct and relevant remedial action to prevent the reoccurrence of the particular accident. These root causes included organisational errors or negligence or problems with management which includes supervision.

**SECTION B: Questionnaire findings**

A sample of 10 Contractors and Health and Safety Officers were surveyed to test if the findings of the case study were in line with what these professionals actually experience on site. The questionnaire was designed to obtain the opinions of these construction professionals regarding the effectiveness of accident investigation processes, the effectiveness of the remedial action taken and if accident investigation methods require improvement.

**4.5 Effectiveness of accident investigation processes**

Table 4.3: Number of construction accidents that occur a month

<b>In your experience, how many construction accidents occur a month?</b>											
<b>Participant</b>	<b>#1</b>	<b>#2</b>	<b>#3</b>	<b>#4</b>	<b>#5</b>	<b>#6</b>	<b>#7</b>	<b>#8</b>	<b>#9</b>	<b>#10</b>	<b>Mean</b>
<b>Response</b>	10	7	10	2	10	5	30	20	15	15	12.4

Table 4.3 suggests that on average participants experienced more than 10 accidents a month, namely 12.4 accidents, which equates to about one accident every second day of a working month.

Table 4.4: Presence of an accident investigation process

<b>Does your organisation have an accident investigation process?</b>	<b>Yes</b>	<b>No</b>
	100%	0%

All participants reported that their organisations had an accident investigation process.

Table 4.5: Effectiveness of accident investigation processes

<b>How effective is this accident investigation process?</b>											
<b>Participant</b>	<b>#1</b>	<b>#2</b>	<b>#3</b>	<b>#4</b>	<b>#5</b>	<b>#6</b>	<b>#7</b>	<b>#8</b>	<b>#9</b>	<b>#10</b>	<b>Mean</b>
<b>Response</b>	1	3	3	3	3	3	3	2	1	3	2.5

Participants were asked to indicate the effectiveness of these accident investigation processes using a three-point Likert scaled where 1= Not effective; 2= Neutral and 3= Effective. The mean response was 2.5 which when rounded up corresponds to a rating of ‘3’ on the Likert scale which indicates that participants find current accident investigation processes effective.

### 4.6 Improving accident investigation processes

Table 4.6: Improvement suggestions of accident investigation processes

<b>What do think should be done to improve accident investigation processes?</b>	
<b>Responses</b>	
More safety checks need to be done	10%
More practical training on how to effectively investigate accidents	20%
Nothing	30%
Improve participation	10%
Improved supervision	20%
Improved communication	10%

From Table 4.6, it is evident that 10% of respondents wanted more health and safety checks, improved participation or improved communication while 20% suggested more practical training on how to effectively investigate accidents or improved supervision and 30% who did not want anything to be improved. This finding suggests that while 30% of participants did not want anything to be improved, the other 70% of participants indicated that accident investigation processes can be improved. This finding indicates that existing accident investigation processes should be re-evaluated and altered in order to improve their effectiveness.

Table 4.7: Impact of improved accident investigation processes on H&S performance

<b>In your opinion, if current accident investigation processes were improved, will it improve health and safety performance on construction sites</b>	Yes	No
	90%	10%

From Table 4.7 it is evident that almost all participants (90%) reported that improved accident investigation processes would improve H&S performance.

Respondents were asked whether there was a lack of interest or a perception of accident investigation processes being tedious and unimportant. Their responses are shown in Table 4.8

Table 4.8: Perception of effectiveness of accident investigation processes

<b>In your experience, is there a lack of interest or a perception of accident investigation processes being tedious and unimportant which tends to make the accident investigation process ineffective?</b>	Yes	No
	40%	60%

From Table 4.8 it was found that 40% agreed that there was a lack of interest or a perception of accident investigation processes being tedious and unimportant. This finding indicates that perhaps not enough importance is placed on accident investigation processes or construction personnel do not understand the importance of accident investigation processes. Participants who find accident investigation processes tedious and unimportant will most likely not conduct the investigation properly which may lead to poor remedial action taken and ultimately resulting in the accidents reoccurrence.

**4.7 Remedial action**

Respondents were asked about how remedial actions were identified. Their responses are shown in Table 4.9.

Table 4.9: Identification of remedial action

<b>How is remedial action identified?</b>	
<b>Response</b>	<b>Percentage</b>
Remedial action is identified based on the analysis of the causes of the accident.	60%
Assessment of consequences and severity thereof	20%
Root cause identification and contributing factors	20%

The findings in Table 4.9 indicate that 60% of participants stated that remedial action was based on the causes identified, 20% stated that it was based on the consequences of the accidents and the severity thereof while the remaining 20% of participants confirmed that remedial action taken is based on root causes. This finding indicates that while 60% of participants identified that remedial action is based on the causes of the accident (which may be direct or contributory causes), only 20% of participants identified and understood that remedial action should be based on root causes of an accident.

Table 4.10: Effectiveness of remedial actions

How effective is the remedial action taken?											
Participant	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Mean
Response	1	3	1	3	1	1	1	1	1	1	1.4

Respondents were asked to indicate the effectiveness of remedial action taken using a three-point Likert scaled where 1= Not effective; 2= Neutral and 3= Effective

The findings indicate that participants generally find the remedial action taken not effective as the mean response is 1.4.

Table 4.11: Remedial action assessed for effectiveness.

After remedial action is taken is it thereafter assessed for effectiveness?	Yes	No
	90%	10%

The findings indicate that 90% of participants agree that remedial action is assessed for effectiveness.

Table 4.12: Perception of fault for accident causation.

In your opinion, are accidents mostly the fault of the worker or supervisor/management?	Worker	Management
	60%	40%

It has been found that 60% of participants indicated that accidents are mostly the fault of the worker and only 40% indicated that fault lies with management.

## 4.8 Summary

This chapter presented the case study of 30 construction accident reports which were analysed to determine which accident causation theories most prevalently or most frequently would have identified the causes as shown in the accident investigation reports. The case study also looked at if the identified causes of accidents were direct causes, contributory causes or root causes and if it was focused on the failures of workers or management. The case study also examined the remedial actions taken to determine if they were able to prevent the accident from reoccurring.

This chapter also included the analysis of the data collected from a survey of a small sample of 10 Contractors and Health and Safety Officers which was aimed at testing if the findings of the case study was in line with what construction professionals actually experience on site.

The findings of the case study and the survey were presented and discussed in this chapter and relate to the hypothesis and objectives of this study.

## CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

### 5.1 Introduction

This chapter draws conclusions on the hypotheses in chapter 1 based on the findings in chapter 4 and will also provide recommendations pertaining to the study.

### 5.2 Summary

This study sought to analyse the causes identified in accident investigation reports in order to determine if the causes identified are correct in order to determine the effectiveness of the subsequent preventative and remedial measures and the prevention of the reoccurrence of the same accidents.

The problem statement that focused the study was as follows:

*Currently, the causes identified in construction accident investigation records might be incorrect resulting in the subsequent preventative and remedial measures being misdirected, ineffective and unsustainable, the outcome of which will not necessarily be the prevention of the same accidents.*

The primary objectives of the study were:

- From a sample of actual records and investigation reports of accidents at a major construction company, to identify the causes recorded of these accidents during the actual investigation process and classify them according to the various causation theories to determine the focus, namely worker or site management of each cause.
- To critically review each accident record and report to determine whether the proposed corrective action would address the actual root causes and would prevent the recurrence of the particular accident.
- From the review to propose corrective measures, if any, to improve accident investigation procedures to correctly identify root causes and propose appropriate preventive measures



### 5.3 Hypotheses Testing

#### **Hypothesis 1: Accident investigations tend to focus on the worker being the primary cause of the accident.**

The findings of the case study indicated that the construction accident investigation reports typically faulted workers as being the root cause of the accidents. This was established as the accident causation theories, models and approaches that appeared most frequently in the analysis of the accident investigation reports namely between the range of 88 and 66 focused on the negligence of workers as being the root cause of the accident. This finding is supported by the survey findings as 60% of participants indicated that accidents are mostly the fault of the worker.

These findings indicate that accident investigation processes are flawed as they predominantly blame the causes of construction accidents on the negligence of workers. Therefore, the hypothesis that accident investigations tend to focus on the worker being the primary cause of the accident cannot be rejected.

#### **Hypothesis 2: Accident investigations fail to identify upstream root causes of accidents that include failures of management and/or organisational errors.**

It was found that the survey participants find the current accident investigation processes and methods effective. However, 70% of participants indicated that it could be improved. The findings of the case study strongly suggest that current accident investigation processes and methods are ineffective as the causes identified in the sample of 30 accident investigation reports were 56% of direct causes, 27% of contributory causes and only 17% of accident investigation reports identified the root cause of the accident.

This finding therefore means that only 17% of accident investigation processes were done correctly and applied the correct and relevant remedial action to prevent the reoccurrence of the same accident as the root causes were correctly identified which refer to organisational errors or negligence or problems with management which includes supervision.

83% of accident investigation reports do not identify the root cause and therefore indicate that accident investigation methods are ineffective. Therefore, the hypothesis that accident investigations fail to identify upstream root causes of accidents that include failures of management and/or organisational errors cannot be rejected.

**Hypothesis 3: Corrective, preventative and remedial actions flowing from completed investigations derive from poorly designed accident investigation methods.**

The findings of the survey indicate that participants find current accident investigation processes effective as the mean response was 2.5. However, the case study findings indicate that accident investigation processes and methods are ineffective as 83% of accident investigation reports incorrectly identified direct and contributory causes which the suggested remedial action was not based on root causes. These findings were supported by the survey findings as only 20% of participants identified that remedial action should be based on root causes of an accident.

It has been found that accident investigation processes are ineffective as they primarily focus on the direct or trigger cause of an accident and not the underlying root cause. This leads to the incorrect remedial action taken. Therefore, the hypothesis that corrective, preventative and remedial actions flowing from completed investigations derive from poorly designed accident investigation methods cannot be rejected.

**Hypothesis 4: Remedial measures arising from investigations will not prevent the recurrence of accidents.**

It has been found that accident investigation processes are ineffective as they primarily focus on the direct or trigger cause of an accident and not the underlying root cause. This leads to the incorrect remedial action taken. Although this remedial action would have helped somewhat in the prevention of the reoccurrence of the accident, it does not address the underlying root cause of the accident which is therefore more likely to reoccur. Therefore, the hypothesis that remedial measures arising from investigations will not prevent the recurrence of accidents cannot be rejected.

### **5.3 Conclusion**

The construction industry is infamously known for its high injury and fatality rates. For many workers, their families and friend's involvement in the construction industry leads to the unimaginable pain and suffering associated with an accidental death or injury (Lingard and Rowlinson, 2005). The same types of accidents occur repetitively in the construction industry around the world. Many of the construction hazards are well known. Despite extensive research on many of these hazards and the establishment of occupational health and safety regulation, construction accidents seem to continue to occur with the same incidence of death, injury and illness. Considering the findings of this study, it can be concluded that these construction accidents continue unabated because the accident investigation processes and methods that are in place which are supposed to mitigate future risk by providing remedial or corrective action are ineffective.

The analysis of causes of construction accidents has found that accident investigation processes and methods are ineffective as 83% of accident investigation reports incorrectly identified direct and contributory causes and not root causes. Based on the findings, the behavioural health and safety interventions or the remedial action taken based on the direct or contributory causes, as part of a health, safety and environmental management system, would not necessarily prevent accidents. Rather they might reduce accidents but not prevent them. Remedial action based on direct or contributory causes and not the underlying root cause may lead to the incorrect remedial action taken. Although this remedial action would have helped somewhat in the prevention of the reoccurrence of the accident, it does not address the underlying root cause of the accident which is therefore more likely to reoccur.

Accidents investigation processes also tend to focus on the worker as being the primary cause of the accident. According to Whittington et al. (1992), emphasis on individual failures resulted in a reliance on short-term solutions rather than uncovering more fundamental management or organisational problems. As much as worker negligence contributes to the cause of the accident, there are further underlying causes such as the lack of training, supervision, health and safety awareness and culture within the organisation, management failing to rotate teams on strenuous tasks and much more that relate to the failure and negligence of management. If these underlying root causes are not addressed these accidents will continue to reoccur.

Given that the intent of any accident investigation should be to prevent the accidents recurrence, all root causes need to be investigated. Clearly the present system of accident investigation and recordkeeping focuses on the downstream event or the last domino in the chain. Arguably, this approach by only addressing the final trigger event or direct or contributory cause will not prevent accidents from reoccurring. Considering that the goal for any construction stakeholder is to strive for zero accidents, any approach which does not prevent accidents is seriously flawed and needs to change.

#### **5.4 Recommendations**

The findings of this study cannot necessarily be generalized to the entire construction industry, but it gives insight into the possibility that other construction companies might be doing the same thing, making the same misjudgements which results in ineffective accident investigation processes and the reoccurrence of accidents. It is therefore recommended that a more in-depth study is done with a larger sample size of different construction companies in South Africa.

It is recommended that accident investigation processes need to be re-evaluated and redesigned to identify root causes and shift the focus of accident causation away from the negligence of workers to the negligence of management to correctly establish remedial action that is relevant and will prevent the reoccurrence of an accident.

## REFERENCES

- Abdelhamid, T.S. and Everett, J.G. 2000. Identifying root causes of construction accidents, *Journal of Construction Engineering Management*, 126 (1), 52-60
- Arboleda, C.A. and Abraham, D.M. 2004. Fatalities in Trenching Operations – Analysis using Models of Accident Causation, *Journal of Construction Engineering and Management*, March/April, 273-280
  - Asanka, W.A and Ranasinghe, M., (2015). Study on the impact of accidents on construction Projects, 6th International Conference on Structural Engineering and Construction Management, Kandy, Sri Lanka, 11Th -13th December 2015
  - Austin, J. 2006. An Introduction to Behavior-Based Safety, *Stone, Sand & Gravel Review*, January/February, 39
  - Bird, F. 1974. *Management guide to loss control*, Institute Press, Atlanta
  - Construction Industry Development Board (CIDB), (2009), Construction Health and Safety in South Africa: Status and Recommendations, viewed 6 February 2017, from <http://www.asocsa.org/publications.html>
  - Dahlbäck, O. 1991. Accident-proneness and risk-taking, *Personality and Individual Differences*, 12 (1), 79-85
  - De Vos, A.S. 2002. *Combined qualitative and quantitative approach*. In De Vos, A.S., Strydom, H., Fouche, C.B. & Delpont, C.S.L. 2002. Research at grass roots: for the social sciences and human service professions. Pretoria: Van Schaik.
  - Durnwald, D.C. (2012). Incident Investigating and Reporting Procedure. BP Oil Refinery, Major Incident Announcement, 3
  - Farmer, E. and Chambers, E. G. 1929. A Study of Personal Qualities in Accident Proneness and Proficiency. *I. H. R. B. Report No. 55*
  - Farmer, E. and Chambers, E. G. 1939. A Study of Accident Proneness Among Motor

- Farmer, E. and Chambers, E. G. 1933. Tests for Accident Proneness. *I. H. R. B. Report No. 68*
- Fellows, R.F. and Liu, A.M., 1997. Research methods for construction. Blackwell Science, ISBN 0632042443
- Geller, E. S. 2001a. *Working safe: How to help people actively care for health and safety (2nd ed.)*. Lewis Publishers, Inc.
- Geller, E. S. 2001b. *Keys to Behavior-based Safety*. Government Institutes, Rockville
- Gibb, A, Lingard, H, Behm, M and Cooke, T , (2014), 'Construction accident causality: learning from different countries and differing consequences', *Construction Management and Economics*, vol. 32, no. 5, pp. 446-459.
- Goddard, W. and Melville, S., 2004. *Research methodology: An introduction*. Juta and Company Ltd.
- Goh, Y. M., Brown, H. and Spickett, J. (2010), Applying systems thinking concepts in the analysis of major incidents and safety culture, *Safety Science*, 48, 302-309
- Hämäläinen, P., Takala, J., and Saarela, K.L, (2006), Global estimates of occupational accidents, *Saf. Sci.*, vol. 44, pp. 137–156
- Health and Safety Authority. 2002. *Fatal Accidents in the Irish Construction Industry 1991-2001: A Survey of Contributory Factors*. Marie Dalton, HSA, internal document
- Health and Safety Executive. 2001. *Improving Health and Safety in Construction. Phase 1: Data Collection, Review and Structuring*. Contract Research Report No. 387/2001

- Heinrich, H.W. 1959. *Industrial Accident Prevention*, McGraw-Hill, New York
- Heinrich, H.W., Petersen, D. and Roos, N. 1980. *Industrial Accident Prevention*, McGraw-Hill, New York
- Hinze, J. 1996. The distraction theory of accident causation, *Proceedings of the 1<sup>st</sup> International Conference on Implementation of Safety and Health on Construction Sites, CIB Working Commission W99: Safety and Health on Construction Sites*, Alves Diaz, L.M. and Coble, R.J. eds., Balkema, Rotterdam, 357-384
- Hinze, J.W. 2006. *Construction Safety*. Alta Systems, Inc., Gainesville, Florida
- Hollnagel, E. 2002. Understanding Accidents – From Root Causes to performance Variability, *IEEE 7<sup>th</sup> Human Factors Meeting, Scottsdale, Arizona*
- Holmes, T. and Rahe, R. H. 1967. The Social Readjustment Rating Scale, *Journal of Psychosomatic Research*, 11, 213
- Hopkins, A. (1995), *Making safety work: Getting management commitment to occupational health and safety*, Allen & Unwin, St Leonards
- Hornby, A.S., Wehmeier, S. and Ashby, M. 2000. *Oxford Advanced Learner's Dictionary of Current English – Sixth Edition*, Oxford University Press, Oxford
- Hosseinian, S.S and Torghabeh, Z.J, (2012), “Major theories of construction accident causation models: A literature review, *International Journal of Advances in Engineering & Technology*, Vol. 4, Issue 2, pp. 53-66, ISSN: 2231-1963
- Howell, G.A., Ballard, G., Abdelhamid, T.S. and Mitropoulos, P. 2002. *Working near the edge: A new approach to construction safety*, In Formoso, CT., Ballard, G. (Eds) *Proceedings of 10th annual conference of the International Group for Lean Construction*, Gramado, Brazil, 1-15
- Hudson, P., 2014. *Accident Causation Models, Management and the Law*, *Journal of Risk Research*, Vol 7 Issue 6, page 749-764

- Hughes, C. 2006. *Quantitative and qualitative approaches* [online]. Available at: [http://www2.warwick.ac.uk/fac/soc/sociology/staff/academicstaff/chughes/hughesc\\_index/teaching\\_researchprocess/quantitativequalitative/quantitativequalitative/](http://www2.warwick.ac.uk/fac/soc/sociology/staff/academicstaff/chughes/hughesc_index/teaching_researchprocess/quantitativequalitative/quantitativequalitative/) (Accessed 31 May 2012)
- IEC 61508 (1998-2000). *Functional Safety of electrical/electronic/programmable electronic safety-related system*, Parts 1 – 7, Geneva, International Electrotechnical Commission
- Irizarry, J., Simonsen, K.L., and Abraham, D.M. (2005), Effect of safety and environmental variables on task durations in steel erection, *Journal of Construction Engineering and Management*, ASCE, 131(12), 1310–1319.
- Katsakiori, P., Sakellaropoulos, G. and Manatakis, E., (2009), Towards an evaluation of accident investigation methods in terms of their alignment with accident causation models, *Safety Science*, Vol 47, p1007-1015
- Kerr, W. 1957. *Complementary Theories of Safety Psychology*, *The Journal of Social Psychology*, 45 (1), 3-9
- Klumb, P.L. 1995. Cognitive failures and performance differences: Validation studies of a German version of the cognitive failures questionnaire, *Ergonomics*, 38 (7), 1456-1467
- Kothari, C.R., 2004. *Research methodology: Methods and techniques*. *New Age International*.
- Krause, T.R. 2000. Moving to the Second Generation in Behavior-Based Safety, *ASSE Professional Development Conference and Exposition, June 25 - 28, 2000 , Orlando, Florida*, American Society of Safety Engineers
- Krause, T. and Hidley, J.H. 1990. *The Behavior-Based Safety Process*, Global Professional Publications, Irvine



- Leedy, P. D. & Ormrod, J. 2001. *Practical Research: Planning and Design*. 7th Ed. Upper Saddle River, NJ: Merrill Prentice Hall
- Lingard, H. and Rowlinson, S. 2005. *Occupational Health and Safety in Construction Project Management*, Spon Press, Oxon
- Mackey, A. and Gass, S.M., 2015. *Second language research: Methodology and design*. Routledge.
- Manu, P., Ankrah, N., Proverbs, D. and Suresh, S. 2010. An approach for determining the extent of contribution of construction project features to accident causation, *Safety Science*, 48, 687-692
- Marks, E., Teizer, J. and Hinze, J. (2014). Near Miss Reporting Program to Enhance Construction Worker Safety Performance, Construction Research Congress
- Mitropoulos, P. Abdelhamid, T.S. and Howell, G.A., 2005. Systems Model of Construction Accident Causation, *Journal of Construction Engineering and Management*, July, 816-825
- Neufeldt, V. and Guralnik, D.B. 1994. *Webster's New World Dictionary of American English – Third College Edition*, Prentice-Hall, New York
- Occupations care South Africa (OCSA). (2016). ALARMING ACCIDENT STATISTICS | OCSA. [online] Available at: <http://www.ocsa.co.za/alarmed-accident-stats/> [Accessed 22 Jan. 2018].
- Ofori, G., 2015. Nature of the construction industry, its needs and its development: A Review of four decades of research. *Journal of Construction in Developing Countries*, 20(2), p.115.
- Organisational Procedure. 2008. *Safety, Health and Environmental Incident Management*.

- Palys, T., 2008. *Basic Research*. The Sage encyclopedia of qualitative research methods, pp.58-60.
- Peckitt, S.J., Glendon, A.I. and Booth, R.T. 2004. Societal Influences on Safety Culture in the Construction Industry, *Construction Safety Management Systems*, Rowlinson, S. ed., Spon Press, London, 17-54
- Perrow, C. 1999. *Normal Accidents: Living with High-Risk Technologies*, Princeton University Press, ISBN 978-0691004129

Petersen, D. 1971. *Techniques of safety management*, McGraw-Hill, New York

- Qureshi, Z.H. 2008. *A review of Accident Modelling Approaches for Complex Socio-Technical Systems*, DSTO Defence Science and Technology Organization, Edinburgh, South Australia
- Rahe, R.H. 1968. Life-change Measurement as a Predictor of Illness, *Proceedings of the Royal Society of Medicine*, 61(11 Pt 1), 1124–1126
- Rasmussen, J. 1997. Risk Management in a Dynamic Society: A modelling problem, *Safety Science*, 27 (2), 183-213
- Reason, J. 1990. *The Contribution Of Latent Human Failures To The Breakdown Of Complex Systems*. *Phil. Trans. R. Soc. Lond. B.* 327, 475-484
- Saleh, J.H. and Pendley, C.C. 2012. From Learning from accidents to teaching about accident causation and prevention: Multidisciplinary education and safety literacy for all engineering students, *Reliability Engineering and System Safety*, 99, 105-113
- SAMTRAC, (2017), HSE Terminology: A Glossary. [ONLINE] Available at: <http://blog.samtrac.com/hse-terminology>. [Accessed 22 January 2018].
- Schramm, W. 1971. Notes on Case Studies of instructional media projects. *Working Paper for the Academy for Educational Development*, Washington, D.C.

- Shavell, S. 1979. Risk sharing and incentives in the principal and agent relationship. *The Bell Journal of Economics*, 10 (1), 55-73
- Shaw, L. and Sichel, H.S. 1971. *Accident proneness: Research in the occurrence, causation, and prevention of road accidents*. Pergamon, Oxford
- Smallwood, J. and Haupt, T.C. 2001. "Safety and Health Team Building," In Coble, Hinze and Haupt (eds), *Construction Safety and Health Management*, Prentice-Hall, New Jersey, 115-144
- Smallwood, J. and Haupt, T.C. 2004. "The New South African Construction Regulations: Multi – Stakeholder Perceptions," COBRA 2004 *The International Construction Conference*, September 7-8, 2004, Leeds, U.K
- Smallwood, J. and Haupt, T.C. 2005. "The need for construction health and safety (H&S) and the construction regulations: engineers' perceptions." *Journal of the South African Institution of Civil Engineering*, 47 ( 2), 2-8
- Suraji, A., Duff, A. R. and Peckitt, S. J. 2001. Development of Causal Model of Construction Accident Causation. *Journal of Construction Engineering and Management*, 127(4), 337-344
- Swuste, P. (2008), "You will only see it, if you understand it" or occupational risk prevention from a management perspective, *Human Factors and Ergonomics in Manufacturing*, 18, 438-453.

The Association for Educational Communications and Technology (AECT), 2001, *The handbook for educational communications and technology*, Bloomington

- Taylor, G., Easter, K. and Hegney, R., (2004), *Enhancing Occupational Safety and Health*, Elsevier Butterworth-Heinemann.
- Tuli, F. 2011. *The Basis of Distinction Between Qualitative and Quantitative Research in Social Science: Reflection on Ontological, Epistemological and Methodological Perspectives*. 6(1) September 2010. Ethiopia: Ambo University.

- Toole, T.M. 2002. Construction Site Safety Roles, *Journal of Construction Engineering and Management*, 128(3), 203-210
- Vicente, K.J. 1999. *Cognitive work analysis: Towards safe, productive and healthy computer-based work*, Lawrence Erlbaum, Mahwah, New Jersey
- Welman, C., Kruger, F. and Mitchell, B., 2005. *Research Methodology*. 3rd ed. Cape Town: Oxford University Press
- Whittington, C., Livingston, A. and Lucas, D.A. 1992. *Research into Management, Organisational and Human Factors in the Construction Industry*. Health and Safety Executive Contract Research Report No. 45/1992
- Wilkens, R. (2011). Construction workers' perceptions of health and safety training programmes, *Construction Management and Economics*, 29(10), 1017-1026
- Williams, C., 2007. *Research methods*. *Journal of Business & Economics Research (JBER)*, 5(3).
- Yin, R.K. 2003. *Applications of Case Study Research*, Thousand Oaks, Sage Publications
- Yin, R.K. 2009. *Case Study Research Design and Methods*, Thousand Oaks, Sage Publications
- Zeller, D. 1986. Heinrich revisited, *Professional Safety*, 31 (10), 40-4

**ANNEXURE A:  
INFORMED CONSENT  
LETTER**

# Information and Consent to Participate in Research

*An analysis of the causes of construction accidents in South Africa: A case study approach*

## To whom it may concern:

I, Trinisha Lutchmiah, am currently registered at the University of KwaZulu Natal for MSc (Masters) in Construction Management. To be awarded my Masters degree, I am required to submit a dissertation on an approved research topic. I have decided to research the causes of construction accidents in South Africa.

Numerous accidents involving loss of life and limb have occurred on construction sites across South Africa. The examination of the causes of accidents is necessary considering the potential consequences of accidents, high casualty rates, environmental damage, economic losses and ethical/moral considerations. Construction activities occur in hazardous working environments with direct exposure to many hazards that are not necessarily present in other industries or working environments. There are a number of theories relative to the causation of accidents on construction sites. Despite these theories, accidents have continued unabated. Poor health and safety (H&S) not only negatively affects workers themselves but also the companies that hire them or for whom they work, their families, and the broader community. This study aims to establish whether the root causes of accidents are identified in accident investigation reports and whether the correct remedial action is taken to prevent accidents from reoccurring.

This study is significant because it will establish if current accident investigation methods are effective or not and if the problem lies with the fault being blamed on the worker and not management or the organisation. It will also determine how accident investigation methods can be improved in order to reduce the number of accidents that occur thereby improving H&S in construction by reducing the number of injuries and fatalities on construction sites and the resultant loss of worker days and associated costs.

You are being invited to consider participating in this study. The study is expected to enrol 10 participants. It will involve a simple questionnaire that will take approximately 5 minutes to complete.

Please note that only a summary of the data collected will be included in the study and that your name will not be included. Your anonymity and confidentiality is of utmost importance. Your participation in this study is completely voluntary. This study is being conducted in my personal capacity as a student. Should you need to contact me regarding any aspect of this research, you can do so by email on: [tlutchmiah@gmail.com](mailto:tlutchmiah@gmail.com)

My academic supervisor is Prof. Theo Haupt, based in the School of Engineering on the Howard campus of the University of KwaZulu Natal. He can be contacted by email at: [haupt@ukzn.ac.za](mailto:haupt@ukzn.ac.za) or telephonically at: 031 260 2712

I would greatly appreciate your participation as it will help me complete this research project.

Kind Regards,

Trinisha Lutcmiah (Student no. 214504554)  
Haupt

Supervisor Prof Theo



---



---

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (HSS/1092/018M).

-----

---

## CONSENT

I \_\_\_\_\_ have been informed about the study entitled The Impact of Induction on overall Health and Safety Performance in the Construction Industry by Trinisha Lutcmiah.

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher. If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

### **HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION**

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

---

**Signature of Participant**

---

**Date**



# **ANNEXURE B: QUESTIONNAIRE**

## CONSTRUCTION ACCIDENT CAUSATION SURVEY

*Your participation in this survey is voluntary*

**1. In your experience, how many construction accidents occur a month?**

---

**2. Do you have an accident investigation process?**

Tick the appropriate box:

YES	<input type="checkbox"/>	NO	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

**3. How effective is this accident investigation process?**

Tick the appropriate box:

Not Effective	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Effective	<input type="checkbox"/>
---------------	--------------------------	---------	--------------------------	-----------	--------------------------

**4. What do think should be done to improve accident investigation processes?**

---

---

**5. In your opinion, if current accident investigation processes were improved, will it improve health and safety performance on construction sites?**

Tick the appropriate box:

YES	<input type="checkbox"/>	NO	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

**6. In your experience, is there a lack of interest or a perception of accident investigation processes being tedious and unimportant which tends to make the accident investigation process ineffective?**

Tick the appropriate box:

YES	<input type="checkbox"/>	NO	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

**7. How is remedial action identified?**

---

---

**8. How effective is the remedial action taken?**

Tick the appropriate box:

Not Effective	<input type="checkbox"/>	Neutral	<input type="checkbox"/>	Effective	<input type="checkbox"/>
---------------	--------------------------	---------	--------------------------	-----------	--------------------------

**9. After remedial action is taken is it thereafter assessed for effectiveness?**

Tick the appropriate box:

YES	<input type="checkbox"/>	NO	<input type="checkbox"/>
-----	--------------------------	----	--------------------------

**10. In your opinion, are accidents mostly the fault or the worker of supervisor/management?**

Tick the appropriate box.

Worker	<input type="checkbox"/>	Supervisor/Management	<input type="checkbox"/>
--------	--------------------------	-----------------------	--------------------------

**Thank you for your participation!**

# **ANNEXURE C: ETHICAL CLEARANCE**

10 September 2018

Ms Trinisha Lutcmiah 214504554  
School of Engineering  
Howard College Campus

Dear Ms Lutcmiah

Protocol reference number: HSS/1092/018M

Project title: An analysis of the causes of construction accidents in South Africa: A case study approach

**Full Approval – Expedited Application**

In response to your application received 9 July 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

**PLEASE NOTE:** Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully



.....  
Professor Shenuka Singh (Chair)  
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Prof Theo Haupt  
cc. Academic Leader Research: Prof Randir Rawatlal  
cc. School Administrator: Ms Nombuso Dlamini

---

Humanities & Social Sciences Research Ethics Committee

Dr Shenuka Singh (Chair)

Westville Campus, Govan Mbeki Building

Postal Address: Private Bag X54001, Durban 4000

Telephone: +27 (0) 31 260 3587/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: [ximbap@ukzn.ac.za](mailto:ximbap@ukzn.ac.za) / [snymanm@ukzn.ac.za](mailto:snymanm@ukzn.ac.za) / [mohunp@ukzn.ac.za](mailto:mohunp@ukzn.ac.za)

Website: [www.ukzn.ac.za](http://www.ukzn.ac.za)



1910 - 2010  
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses:  Edgewood  Howard College  Medical School  Pietermaritzburg  Westville