



AN EVALUATION OF FACTORS TRIGGERING ACCIDENTS ON CONSTRUCTION SITES.

BY

OPEYEMI AYOBAMI DAVID

STUDENT NO: 22064921

SUPERVISOR: DR IRUKA C ANUGWO

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DECLARATION

I, **Opeyemia Yobami David**, declare that this dissertation is an original outcome of my research study. I also declare that the sources used in this research have been duly acknowledged in the references list and adequately cited in the body of the dissertation. The copies of this research work have not been submitted elsewhere for any similar purpose. This research study was carried out at the Durban University of Technology as a requirement to obtain a Master of the Built Environment degree in Construction Management under the supervision of Dr I.C Anugwo.

Submitted by

13th May 2025

Mr OY David

Date:

13TH May 2025

Supervisor: Dr IC Anugwo

Date:

14 May 2025

Prof. MS Ramabodu (HoD)

Date:

ABSTRACT

The Construction Industry (CI) continues to be one of the most physically demanding and risky industries, especially in developing countries where construction activities are more labor-intensive and key issues of health and safety are not adequately addressed when compared with construction practice in the developed countries. Reports of fatal occupational health and safety incidents in the South African construction industry indicate an increase in construction site accidents. This study aims to identify key factors contributing to construction site accidents and propose effective management strategies for mitigating occupational injuries in KwaZulu Natal's construction sector. Thus, this study adopted a quantitative research method, utilising the questionnaire survey as a data collection tool. A purposive sample size of 100 South African Council for the Project and Construction Management Professions (SACPCMP) practitioners were recruited as respondents. Out of the 100 questionnaires distributed among the respondents, only 65 were filled out, returned and valid, yielding a response rate of 65%. The data collected was analyzed using percentages, mean scores and standard deviations, and all the questions contained in the questionnaires were rated using the SPSS statistical package. Study findings indicate that poor scaffolding, contact with energized power sources, and substandard materials significantly contributes to construction site accidents. These issues have key resultant effects such as the cost of case litigation processes, damage to plant and equipment, damage to the reputation of the employer, settlement payments for injuries and death, and the disruption of site operations. This study recommends enhanced training, stricter safety regulations and improved site inspections as key measures to reduce accident rates. However, the study further recommends structured training programs, policy enhancements and stricter enforcement of safety standards to mitigate site accidents and improve construction safety culture in South Africa.

Keywords: Accidents prevention strategies, construction safety, health and safety, risk mitigation, workplace safety, health and safety,

DEDICATION

This research is dedicated to God almighty, my supporting dad and every member of the David family.

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CHAPTER ONE: INTRODUCTION AND STUDY BACKGROUND

1.1 Management Strategies for Construction Site Accidents in Kwa Zulu- Natal

The South African construction industry plays a significant role in the development of infrastructure and overall gross domestic product (GDP) and the economic growth of the country (Construction Industry Development Board (CIDB), 2012; Aiyetan, 2012; Windapo and Cattell, 2013). The construction industry creates employment even for the least skilled members of the society, and it also plays a role in the development and transfer of technology, creating many opportunities for enterprises, and contributes directly to the overall improvement of the quality of life of any given society (Aiyetan, 2012; Windapo and Cattell, 2013; Anugwo, 2017).

Construction activities typically involve projects such as residential buildings, health-care and educational facilities, airports, bridges, roadways, excavations, and demolitions. The construction industry (CI) has displayed phenomenal growth globally in the last decade. The nature of the growth reflected activities such as innovative construction design, alterations, and maintenance (Emad, *et al.*, 2020). Despite the growth in the construction sector, the construction activities have been described as a high-risk industry due to health and safety (H&S) concerns (OSHA, 2018).

Health and safety issues on construction sites are of significant concern due to the increasing rate of occupational injuries and fatalities stemming from accidents on construction sites when compared with other industries (OSHA, 2018). Although substantial improvement has been achieved in occupational safety, it is still challenging to manage and control the risks in construction activities due to the inherent nature of activities being probed due to risk. Thus, accidents in the construction industry often have severe consequences for the workers, their families and the public (OSHA, 2018).

Kalatpour and Khavaji (2016) claim that in developing countries, attention to health and safety issues on construction sites is very low, as most tasks are performed manually. Inadequate H&S measures result in significant exposure to occupational hazards. Additionally, there is the issue of poor record-keeping of H&S incidents when measured against international standards (Kalatpour and Khavaji, 2016).

Aiyetan (2012) states that the South African construction industry is currently experiencing an increase in the size of project complexity, technology, and more variation in the design requirements from clients. These changes have led to the rise in the employment of untrained, unskilled and unlicensed construction workers, which has resulted in the high number of accidents on the construction sites. These phenomena have resulted in a demand for high-level professionalism in the implementation of H&S practices in the built environment sector (Aiyetan, 2012).

1.2 Research Problem Formulation

Syed (2015) states that construction site accidents vary from one project to another, which means that construction sites could be more prone to risk-related accidents with each other. Health regulations and safety issues in the South African construction industry have been the focus of attention from its various stakeholders and major role players by a non-improving situation. Despite ongoing efforts by the stakeholders and role players, the South African construction industry is characterized by a high degree of non-compliance with health and safety legislation, consistently resulting in an increasing number of fatalities and injuries as compared to other industries.

John *et al.* (2010) further found that the South African construction industry needs a shift in its mindset to become more health and safety conscious to improve a situation where at least two workers die on site due to accidents every week. There is a need for a change in the way construction projects are carried out on site to prevent and mitigate the occurrence of accidents, thereby improving health and safety conditions in the industry.

In comparison to other industries, the construction industry has recorded more violations of health regulations and safety issues related to construction risks. Thus, evidence indicates that accidents on construction sites are mostly caused by unsafe activities and conditions within construction activities, and this issue is more prevalent in developing countries, including South Africa. In addition, most construction activities on sites involve manual labor; safety laws are not strictly enforced; and contractors ignore basic safety rules and regulations. These actions of contractors and construction workers are what lead to accidents most of the time, and these accidents in turn result in suffering for the

individuals who have been involved in these occurrences, as well as economic hardship, a lack of motivation to work, and legal action against the management of the project, which ultimately causes a delay in the delivery of infrastructure. The following includes the major problems of accidents that often occur on construction sites in the construction industry. in Durban, KwaZulu-Natal (John *et al.* 2010).

The following are the major problems of accidents on construction sites that affect the health and safety conditions in the construction industry:

- Falling object accidents
- Falling from heights and scaffolding accidents
- Electrocution accidents
- Structure collapse accidents
- Crane accidents
- Vibrating tool accidents (Ramaya and Ramadasan 2016).

1.2.1 Research Problem Statement

The past and recent records of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry are an indication that effective management strategy for the prevention of construction site accidents is not well understood and implemented by practitioners.

1.2.2 Sub Problems 1

The inadequate assessment of the causes of accidents in KwaZulu-Natal's construction industry has resulted in an increased number of fatalities (John *et al.* 2010).and other health issues among the workers during the delivery of projects due to poor record-keeping.

1.2.3 Sub Problem 2

The impact of accidents in the KwaZulu-Natal construction industry has increased, which includes project abandonment and worker incapacitation, leading to a shortage of skilled

labor and ultimately death. This emphasizes the detrimental consequences of accidents and their adverse effects on the health and safety conditions of the industry.

1.2.4 Sub Problem 3

The ineffective preventive measures put in place in the KwaZulu-Natal construction industry have resulted in an increased occurrence of accidents on construction sites, which is also tied to the fact that there is a very low degree of regard for regulations on construction sites.

1.3 Research Question

The following questions will serve as a guide for this study to address the identified problems:

- What are the various causes of the construction site accidents in KwaZulu-Natal's construction industry?
- What are the critical effects of construction site accidents on workers and projects in the KwaZulu-Natal construction industry?
- What are the various preventive and action-orientated strategies for the effective mitigation of construction site accidents in KwaZulu-Natal's construction industry?

1.4 Aim of The Study

The aim of this study is to assess effective management strategies for the prevention of accidents, occupational injuries and related risks on construction sites in KwaZulu-Natal's construction industry.

1.5 Objectives of The Study

The objectives of the study are:

- To identify and assess the causes of construction site accidents and occupational injuries in KwaZulu-Natal's construction industry.
- To assess the resultant effect of construction site accidents and occupational injuries among workers in the KwaZulu-Natal construction industry; and

- To assess and recommend strategies that would assist in mitigating construction site accidents and occupational injuries in KwaZulu-Natal's construction industry.

1.6 Significance of The Study

Health and safety regulations are critical in the construction industry to protect workers, reduce accidents and injuries, ensure legal compliance, and improve productivity. Employers who prioritise health and safety are more likely to create a culture of safety and promote a positive work environment that benefits both the workers and the company (OSHA 2016; NSC 2019; CPWR 2018). There is a wide range of variation in the economic structure, working conditions, working environment, and health status of the workers in different sectors of the economy. The activities of the construction industry play a vital role in boosting the economy of any country, especially in the developing countries, as it provides the infrastructure required for other sectors of the economy to function and flourish. Taucha (2006) further states that the problems of accidents on construction sites have proven to be an issue for the industry and require preventive strategies to curb the challenges. Thus, safety is very important in all disciplines and must be prioritised in any vocation or activity of practice in life. If safety is not considered first, adverse outcomes may result from any endeavour, safety regulations and practices must be adhered to and complied with to maintain quality and cost parameters in the delivery of a project.

The importance of this study is noted as it seeks to investigate the causes of each major accident on the construction site; it seeks to investigate the factors that could be considered to prevent them and also assess and investigate the factors that could be considered to mitigate the occurrence of these accidents and finally to develop a model that would be used to predict accidents in the delivery of infrastructure in the South African construction and building industry. Criticisms of the construction industry have arisen because of projects that have taken a longer time to complete than stipulated (Aiyetan, 2012). This can be traced to the occurrence of accidents on construction site. The consequences of these accidents in the delivery of infrastructure are grave, from fatality to loss of time and enthusiasm of the workers involved. Accidents on construction site can also lead to legal action against the management in charge of construction projects and accidents also lead to budget overruns.

The construction industry is the bedrock of all other industries in the sense that the construction industry provides the infrastructure and facilities for all other industry to function. As stated earlier, the issue of accidents on construction site has proven to be a problem in the construction industry. The importance of this research can be noted as it seeks to address the issue of on-site accidents, which often lead to non-delivery.

The significance of this study is highlighted in the depth of investigations carried out in discovering and understanding the various causes, effects and possible means to prevent the occurrence of accidents such as falling object accidents, fall from height accidents, scaffolding accidents, electrocution accidents, structure collapse accidents, crane accidents and vibrating tools mishandling accidents on construction sites in the KwaZulu-Natal province of South Africa.

1.7 Scope of The Study

This study examines construction site accidents and occupational injuries, such as falling from heights and falling objects, scaffolding, electrocution, structure collapse, crane and vibrating tool mishandling accidents, and their causes, effects, and prevention in KwaZulu-Natal's construction industry.

1.8 The Outline of The Study

Chapter One: Introduction: In this chapter, fundamental issues causing construction site accidents were presented and discussed, which led to presentation of research problem formulation and statement, the sub-problems, research questions, aim and objectives. This section further presented and discussed the significance of the study and research scope accordingly.

Chapter Two: Literature Review: In this chapter, the related and relevant literature resources on the key concepts, theories, ideas, opinions, debates and perspectives on the subject matter under investigation were presented and discussed.

Chapter Three: The Research Methodology: In this chapter, the research methodology, methods, approaches and techniques used to design, justify and collect data from the respondents, and how the research instrument—questionnaire survey—was

administered for data collection. The justification for adopting a particular research method, technique, approach, population size and sample was discussed accordingly.

Chapter Four: Data Analysis and Discussion: Chapter Four presented the data analyses and discussion of the research findings. The findings are discussed and validated by comparing them with existing literature, thereby enriching the body of knowledge.

Chapter Five: Summary, Conclusion and Recommendations: This chapter presented and discussed how the research objectives were achieved. The key summary that emanated from study results, which led to the conclusions and recommendations, and areas of further research studies were also discussed.

1.9 Concluding Remarks

This chapter forms one of the core areas of this research endeavor on construction site health and safety as well as occupational injuries and risks associated with the construction working environment. Thus, the research problem, the sub-problems, aim and objectives, and the significance of the study were discussed.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In terms of employment level, economic activities and contribution to national development, Aiyetan (2012), citing Stem and Teljeur (2002) declares that in the last decade, the construction and building sector has contributed 3% to the gross domestic product. This is lower than the agriculture sector's contribution of 4.2% and higher than the manufacturing sector's contribution of 20%. This makes the construction industry the third highest contributor to the national economy and also the most important industry, because it provides the infrastructure that other industries need to operate.

Ajasa (2012), citing the International Labour Organisation (ILO), states that there are at least 60 000 accidents yearly on construction sites around the world, with one fatal accident every ten minutes. The top five causes of accidents are: lack of awareness of safety-related issues, lack of personal protective equipment, lack of safety hazards elimination in design, unfit equipment, and lack of knowledge and training on equipment, respectively. An accident can be defined as an unexpected event with negative consequences without the intention of inflicting harm on the one suffering the consequences. It is an unintended event such as collision that causes damage or death, and could result in injuries, death, occupational illnesses or damage to property. The five major effects of accidents are: loss of human lives, loss of motivation of workers reduce morale, conflict with workers, loss of productivity of project, and delay in work progress, respectively (Shakil, 2019).

An accident on a construction site, therefore, is an unexpected event with negative consequences occurring without the intention of those involved in the process of construction. An accident on a construction site could be a direct result of management actions on construction activities; it could also be the direct result of workers actions, and it could also be a result of natural occurrence Sivaprakash, P, & Kachana, S, (2023) . These accidents can be mitigated to a very large extent or totally prevented. This chapter discusses the causes, preventions and mitigations of accidents on the construction site in the KwaZulu-Natal province of South Africa.

2.2 An Overview on Various Causes of Accident on Construction Site

Worksafe (2017) stated that falling objects are leading causes of accidents that result in death and serious injury on the construction site. It poses a risk to workers on site and to persons around the site. Objects falling from heights can cause serious and fatal accidents. Examples of objects that could fall and hit workers at lower levels include free-falling objects from a structure, such as roof scaffolding, tools, rocks, soils and bricks; free-falling objects from plants or loads falling from lifting machines while they are being lifted up; and objects ejected while using machines or hand tools and the collapse of an unstable structure or part of a structure (Worksafe, 2017).

2.2.1 The Causes of Falling Object Accidents at Construction Sites

The common causes of falling object accidents are discussed as follows:

Missing toe on scaffolding/kick boards on scaffolding: Nadhim *et al.* (2016) declare that workers working on elevated levels on construction sites usually stand on boards as platforms to work. These workers could slip on the boards, kick objects, lose balance and fall, posing a danger to workers or passersby at lower levels (Nadhim *et al.*, 2016).

Debris and materials falling from plants or loads while being lifted: Ajasa (2019) states that both the employer of labour and the employee on construction sites are legally liable for the act of negligence. The occurrence of materials falling from plants or loads and striking workers at a lower level while they are being conveyed either vertically or horizontally could, to a high degree, be a result of negligence on account of the operator (Ajasa, 2012). These could be prevented by the employers through rigorous testing and by employing professionals and certified labourers. Debris and materials are ranked as one of the major causes of falling object accidents (Simudah & Abas, 2024).

Holes in safety netting/gaps between perimeter safety screens: Gaps between safety screen or holes in safety netting pose the risk of objects falling from higher levels exposing those at lower levels to the risk of being struck. Holes in safety netting should be mended and gaps between perimeter safety screens should be closed before they are used. This calls for thorough inspection of these working aids (Simudah & Abas, 2024; Ajasa, 2012).

Being blown from structure by wind: Windstorms have the capacity to blow away things. Wind-blown objects from elevated heights on construction sites are common and very dangerous. These exposes both the workers on site and passersby to the risk of being hit by a falling object (Worksafe, 2017).

Material left at edges unsecured: Wu and Li (2024) state that materials (tools and input) remaining afterwork at the site must be stored securely. Unsecured materials, for example hammer, bricks and other construction tools could easily fall of those edges, thereby exposing both workers on site and person's passing by to the risk of being struck. Wu and Li (2024) also note that another source of construction worker accidents is related to workers operating without any proper training and measures to control the occurrence of falling object accidents on site. A construction worker working on site without any proper training is at risk not only to himself but also to other workers on site and passersby. The workers passing by lack the knowledge to protect themselves and others on site. This act could be considered an act to negligence. Training is a very important factor for ensuring safety on site.

2.2.2: An Overview on Causes of Fall from Height Accidents and Scaffolding/ Ladder Accidents

According to Nor *et al.* (2020), the construction industry is perceived as one of the most hazardous industries in many parts of the world. It is characterized by frequent accidents on construction sites from scaffolding, ladders and electrical and power tools. Safety and health issues in the construction industry need to be considered mainly due to the high demand for high-rise buildings in countries worldwide. Block and Murphy (2019) state that more than two million construction workers across the United States of America use scaffolds. Block and Murphy quote the Bureau of Labour Statistics Reports, that nationwide, scaffolding accidents in the USA contribute to more than 60 deaths and 4 500 injuries every year.

Causes of scaffolding/ladder accidents in the construction industry are as follows:

Insufficient or lack of training: Nor *et al.* (2019) state that proper training for employees is the key to ensuring safety on construction sites. Many project managers assume that all

workers are aware of construction site safety procedures at work. Unfortunately, most of them are untrained and new employees are not being trained. As a result, it is impossible for them to complete their tasks well; therefore, mistakes are inevitable. Proper training should be implemented. This contribute to an increase in cases of injuries and fatalities at construction sites (Nor *et al.*, 2019).

Weak planking: Enshassi and Shakalah (2015) state that planking set-up is one of the important parts for scaffolding, as it holds all of the temporary loads; most accidents associated with scaffolding are directly related to faulty planking. If the scaffolding planking is unsafe, insecure, in poor condition, or overloaded, it could lead to a scaffolding accident. The strength of the planking to be used should be determined against the expected load to carry. It must be inspected to identify weak spots and adequacy for use to avoid accidents before usage (Enshassi and Shakalah, 2015).

Insecure bracing: According to Regulations 77 of BOWEC (1986), every scaffolding should be securely supported or suspended and, where necessary, sufficiently and properly struted or braced to ensure stability. Nor *et al.* (2019) state that the use of bracing in scaffolding for support and stability is critical. It has been established that working on an insecurely braced scaffolding is dangerous for workers and poses the risk of death or serious injuries.

Overloading: Nor *et al.* (2019) state that the scaffolding accident in Australia in 2009 was due to overloading a brick-filled platform. Williams *et al.* (2018) identified overloading as one of the ten major causes of construction collapses impacting structure as well as scaffoldings. Experience and information dictate that the quantity of load per time on a scaffold platform should be known and not exceeded. It should be remembered that the weight of the worker and the materials to be placed on the platform must not exceed the recommended weight at all times (Nor *et al.*, 2019).

Ignoring safety rules: Accidents on construction sites can happen at any time and could lead to serious injuries to the workers. The means to prevent the occurrence of these accidents is to pay attention to all safety rules. Kachana *et al.* (2015) declare that all

equipment, tools and devices have safety rules, and the lack of adherence to safety rules leads to misuse, damage, and possibly accidents.

Incompetent erector. Nor *et al.* (2020) reveal that improper installation of the scaffolding by an incompetent installer may result in the faulty installation, which may not meet installation standards. This can, in turn, lead to turnover and displacements of frames in their connections. Imperfect scaffolding can lead to decreased load capacity due to scaffold components bending, thus affecting the stability of the scaffolding. They further stated that an inadequate spatial structure of a material agent results from the incorrect assembly of scaffolding.

The main irregularities include the lack of vertical communication divisions that allow safe movements of workers between the levels of the working platform, the lack of a full working platform and necessary structural elements such as anchors, struts, handrails and platforms. Without these in place in their inadequacy and rigidity may lead to accidents as work is being performed on it. Nor *et al.* (2020) found that the most frequent causes of fall accidents include ignoring safety rules, conducting improper inspections and having inadequate foundation stability. Rajendran (2019) ranked the areas on site with the most frequent fall incidences with scaffolding recording the highest falls, followed by falls from ladders and then falls from roofs. He also ranked the causes of these accidents according to their high frequency: working at elevated heights without protected sides and edges and poor housekeeping to be the most frequent causes of fall accidents. Hola *et al.* (2017) identified the lack of protective barriers as the main cause of falls from heights and scaffoldings. They also found that the most common causes of these accidents arise from the use of faulty PPE, violation of existing regulations and defect in scaffolding structure. Nor *et al.* (2020) found that the highest occurrence of all accidents included falls from heights, ladders and scaffoldings.

2.2.3 An Overview on Electrocution and Its Causes as A Part of Construction Accident

Electrocution is an act induced by an electric current. Electricity brings significant benefits to the population, but when misused, it can pose a significant danger, especially regarding safety. Safety is being risk-free. Despite several safety standards and regulations in place

to ensure safety in work involving electricity, there are still many accidents that range from minor injuries to fatalities due to electrocution accidents OSHA (2011) defines electrocution hazard as a serious workplace hazard that exposes workers to the following: burns, electrocution, shock, arc flash, arc blast, fire and explosion. These occur when a person is exposed to a lethal amount of electrical energy. The after-effects of electrocution may include deformation, which could hinder work performance or even result in death.

Babek *et al.* (2022), citing OSHA (2011), state that contact with overhead power lines, faulty wiring, contact with energised equipment, improper personal protective equipment (PPE) and faulty construction tools are the leading causes of occupational injuries from electric shock. Wang *et al.* (2018) found that 36% of electrocution deaths in the construction industry were caused by direct exposure to more than 220 volts of electricity between 2011 and 2015. While 34% of the deaths by electrocution were caused by indirect exposure, they found that 23% of deaths arising from electrocution accidents were caused either indirectly or directly by exposure to less than 220 volts of electricity. The remaining 7% was due to other causes.

Contact with overhead power lines: Contact is physically touching things, working in the vicinity of high-voltage power lines, working on a ladder, or in a suspended main basket that takes you near power lines, all pose risks of electrocution. Extreme caution is required in order to avoid contact with electric energy that leads to hazard. Workers must comply with the use of PPE to mitigate against electrocution accidents (OSHA, 2011). Working in the vicinity of high-voltage power lines, working on a ladder in a main basket suspended in a crane basket and being very close to electric cables poses a risk of electrocution.

Contact with energized sources: Sources of power must be insulated to avoid direct contact with them. The major hazards regarding contact with energized sources are electrical shocks and burns. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of the electrical circuit, a wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor (OSHA, 2011).

Improper use of extension and flexible cords: The normal wear and tear on extension and flexible cords can expose wire, creating a hazardous condition. Cords that are not three-wire types are not designed for rigorous usage and can increase the risk of being in contact with electrical current. The construction industry is characterized by a high use of power tools, often necessitating the use of flexible extension cords (OSHA, 2011). Extension cords and flexible wires are susceptible to quick damage; regular checks are required to identify any exposed parts of these cords. Scott *et al.* (2019) state that the number of electrocutions in the construction industry can be compared to the total number of electrocution accidents experienced in other industries put together. They further stated that the Centre for Construction Research and Training (CPWR) found that the total number and rate of electrocutions in the construction industry fell from 2003 to 2015 (CPWR 2017). This decline in the rate of electrocution accidents, which is estimated to be around 40%, could be traced to economic recession, such as fewer workers being employed. In addition, the construction industry is still very much burdened with the problem of electrocution accidents and their hazards more than any other industry.

2.2.4: An Overview on Issues of Structural Collapse as A Part of Construction Accident

Ayodeji (2019), referring to Fadamiro (2002), defines building as an enclosure for spaces designed for specific use, meant to control local climate, distribute service, and evacuate waste. He further defines building as a structural entity capable of securing itself by transmitting weights to the ground. Therefore, building can be defined as a structure for human activities, which must be safe for the occupants. One type of accident that occurs on construction sites worldwide is structure collapse. Construction sites face the risk of structural collapse both during and after construction. Structural collapse occurs when a whole building or part of it fails. Ayodeji (2012) further states that building collapse is an extreme case of building failure; it may mean the super-structure crashes down totally or partially.

Various authors have identified the causes of building/structure collapses. Lewis and Alexander (2018) affirm that building collapses occur all over the world at different

locations and at different times, but the frequency of their occurrences is quicker, and the consequences are more grievous and felt more in developing countries. The causes are:

Brief and Design deficiencies: Ayodeji (2012), citing Fadamiro (2002) states that the inadequacies in the brief of a client can bring about defects in the project even at the inception of the project. The inadequacies include the client failing to give all the necessary information on the functional requirements of the building, structural deficiencies that fall under calculation errors, which may reveal bearing support problems in assumed loading. All of these factors contribute to building collapse and failure.

Awoyera (2021) presents another view: man-made conditions and natural conditions are the causes of buildings or structures collapsing. He further states that these manmade conditions include the failure to award contracts to professionals in the construction industry who are registered with the relevant bodies, Inadequate adherence to professional building codes and also poor supervision or inconsistent supervision, are also contributing factors.

Natural occurrence: Rainfall, wind and temperature are all-natural factors, which if not properly managed, could negatively affect a building, resulting in the collapse of the building or a part of the structure. Tall buildings are designed to conceal the roof from the wind by incorporating parapet walls.

Substandard Materials: Odeymi and Rasheed (2019) declare that the incorporation of substandard materials in the construction process would cause buildings to be deficient in stability and result in their collapse. The incorporation of poor-quality materials into the construction project introduces weak zones and points of failure in the structure that may lead to collapse.

Poor skilled labor: Incompetent craftsmen instead of professionals being involved in the construction process could very much result in accidents involving structure collapse. Supervisors, site agents and managers must be qualified personnel and have adequate experience to ensure safety and the safe delivery of the project.

Excessive loading: Odeyemi and Rasheed (2019) citing Osegbale *et al.* (2015) state that cracking of the concrete structure, which is the result of overloading, could directly lead to the collapse of a building, which, in turn, is also a direct result of incompetent labor and deficiencies in the client's brief. It is important that adequate soil testing of the site be conducted to determine the bearing capacity of the soil structure, and these be used in the design of the structural element of the project.

Oke (2019) found that buildings fail mainly through ignorance, negligence and greed. Ignorance is a direct result of incompetent personnel; negligence is continuing with the construction without making all the necessary checks, while greed is the diversion of building funds for personal gain on the part of the contractor.

Poor materials and workmanship were the most frequent causes of building collapse, followed by excessive loading and design error (Oke, 2019).

2.2.5 Understanding the Main Causes of Crane Accidents in the Construction Industry

Sahihu *et al.* (2020) state that crane accidents occur on site as a result of not following the operational processes specified by the crane manufacturers either during installation or usage. Improper assembling, insufficient numbers of workers involved in the crane operation in respect of giving of signals, installing and dismantling with speed to meet appropriate time required for a safe process and consistency without omission of safety regulations are some of the causes of crane accidents.

Crane accidents have increased following the demand for transporting and lifting heavy materials. Cranes are needed for earth/soil moving, carrying machines that are used for heavy building material lifting and equipment transportation. The causes of crane accidents can be categorized under four main headings: human factors, environmental factors, poor safety management related factors, and technical and operational factors.

Human factor: These accidents occur due to the workers' attitude to working on site. The factors that contribute to the human factor source of accidents are poor communication, operator's carelessness, poor work supervision, and obstruction of vision.

Environmental factors: This type of accident occurs in an environment that is not conducive to working with the crane on site. These environmental factors include the following: Hazardous weather condition—resulting in poor visibility, a tight working environment, a congested site limiting the movement of the crane; and an unsanitary and disorganized working environment—non-sequenced plan of work may lead to confusion and accident.

Poor safety management refers to the following:

- Being ignorant of a faulty crane. This is the use of a crane having a fault without the knowledge of the operator. This could cause a crane accident
- Non-compliance with safety measures stated in the guidelines for working on a crane; and
- Crane being operated by unqualified and uncertified operator

Technical and operational factors: The factors below are technically inclined factors that cause the crane accidents: Failure of the crane stops' track and buffer, the loading ropes, the motorized and adjustable lifting system, crane platforms not adequately installed, overloading of crane, and the use of components that do not fulfill the required technical specifications. Sabri and Whahid (2018) found that lack of maintenance was the highest cause of crane accidents, followed by poor state of crane wire and operation by an inexperienced operator handling the crane as the third most frequent causes of crane accidents.

2.2.6 An Overview of Issues Related to Vibrating Tools Accident in Construction

The International Social Security Association (2010) revealed that exposure to vibrations may affect people in a variety of ways, ranging from mere annoyance to impairment of performance, a health hazard, and damage to their health.

The extent to which individuals are exposed to vibrating tools depends on the following: intensity of vibration, frequency, duration of exposure, working techniques, and types of activities. The causes of vibrating tool accidents can be categorized into two main causes: vibration and whole-body vibration.

Hand and arm vibration: Chigangacha *et al.* (2023) define hand and arm vibration injury as an injury that occurs when the vibrating tool is held in the hand. As the vibrating tools are hand-held and are used over a long period of time, it leads to hand and arm injuries. Examples of those tools include grinders, clipping hammers, rammers, drills, and chainsaws. The damage that hand and arm vibrating tools cause is permanent vibration of the hand and arm; this results in workers not being able to have a firm grip on equipment and materials for work and may cause accidents.

Whole body vibrating injury: In this category, the vibration affects the whole body as the vibration is transmitted through the feet to the whole body in the case when working while standing, or the head and back while working in a supine position. This vibration can also be transmitted through the buttocks or back when performing sedentary work. Examples of machines that could cause whole body vibration include construction site lorries, forestry machines, graders, wheel tractors, and fork-lift trucks (Chigangacha *et al.*, 2023).

These all lead to a lack of stability and trigger accidents. The vibration of these machines occurs mostly while working on uneven grounds; the effect of this vibration on the operators includes the following: circulation disorder, nerve function disorder, muscle tissue changes, bone and joint damage, visual disturbance, spine effect, stomach upset, reduced performance, and impaired sense and balance disorder. These put together may lead to instability and the inability to concentrate on work and this ultimately results in accidents through mistakes made by the worker.

Workers who consistently work with tools with a frequency in the range of [60-300H³] are more likely to develop symptoms of hand and arm vibrations, while those working consistently with tools between [10-60H³] are more likely to be affected by loss of muscle mass and joint injuries (Kranjnak, 2018).

2.3 An Overview on Major Effect of Accident on Construction Site

Ajasa (2012) states that accidents in the construction industry fall into three major categories: humanitarian, economic, and legal factors.

Humanitarian effect: The humanitarian effect of accidents deals with the direct consequences of the accidents on the construction worker involved. The effects include hardship of individuals, minor injuries, disabling injuries, loss of earning potential, and fatalities.

Economic Effect: The economic effect of accidents on the construction industry includes project delivery delay, legal expenses, time loss by the employee, time spent in training a temporary or permanent staff replacement, and time spent by management in investigating and responding to accidents.

Legal effect: Ajasa (2012) enunciates that the legal effect of an accident can be predicated on accounts of negligence by the employers of labour and employees on construction sites. Legal liability includes failure to safeguard employees, which is a criminal offence liable to prosecution.

Abdulhamid *et al.* (2005) and Hurny and Hinze (2003) identify the effects of falling object accidents, and they include the following: stress and sprain, fracture, back injuries, burns and cuts and fatalities.

Strain: This type of injury usually occurs in the lower back and muscle in the back of the thigh; it is the tearing of muscles or tissue connecting to the tendon as a result of accidents involving objects falling from elevated levels. When this occurs, the injured worker's efficiency is reduced, which ultimately decreases his productivity. Therefore, fulfilling the duty of meeting daily output—a vital factor—becomes difficult and could lead to project delivery delays.

Back injury: Abdulhamid *et al.* (2005) describe back injury as the type of injury related to sprain and strain injuries but occurring on the back and could result from falling object accidents. A worker who has been affected with a back injury would find it impractical to carry on with work on site.

Fracture: Abdulhamid *et al.* (2005) define fracture as a break in bone or cartilage. Hurny and Hinze (2003) define a fracture as a severe injury that could occur on site as a result of an object falling from a height to strike a worker at a lower level. When this occurs, its

effect on the project could be humanitarian in terms of severe pain and hardship experienced in the health and well-being of the worker involved. Its economic effect is such that unbudgeted money would be spent on training a new worker and treating the injured worker; a delay would be experienced in the project timing. If the employer is found culpable for failing to protect workers from job hazards, it could lead to legal consequences.

Fatalities: The tendency for destruction or danger on a construction site is serious and could result in death. The death of a worker on a construction site could mean the end of a project and trigger an investigation into the employer. This investigation might determine negligence, potentially resulting in the withdrawal of the licence to practice as legal actions would be taken after the investigation into the employer.

2.3.1: Effect of Fall from Height Accident on Construction Site/Scaffolding Accidents

According to Oladele (2014), falls from elevated heights on construction sites are responsible for more than 50% of accidents that occurs there.

Numahamira *et al.* (2020) declare that the main effects of accidents are felt by the workers who are injured and could sometimes lose their lives to the accidents. The impact on the project may include loss of time resulting in project delay and the effect on workers of fall from height accidents includes strain, back injuries, fatalities, fractures, burns and cuts, fatalities, and legal expenses.

An employer may face legal actions after investigation into an accident on site if it is established that the employer was negligent about protecting the employers from the hazards that they are exposed to on site or making provision for protective aids for the workers.

Project delay: Chigangacha, Edwards and Haupt (2023) define project delay as the lingering of projects due to inactivity, which may be a direct result of workers being involved in an accident and incurring either permanent or temporary injury or death. An accident on site can lead to a serious injury or ultimately death. This reduces the work force on site and affects the project timing, as the project will be stopped in order to carry

out investigations and sometimes to face legal actions if it is discovered that the employer failed to protect workers due to negligence and the workers were exposed to hazardous conditions.

Loss of time to the employee: Time is lost when the project has to be stopped either temporarily or permanently as a result of an accident. In the case where the worker involved dies or is permanently disabled because of an accident, time is lost in the legal process, because workers have to file claims against their employer, stemming from the investigation into the cause of the accident, and blame is apportioned.

Nadhim *et al.* (2016) found that fractures and trauma were the most common effects of fall-from-height accidents on workers, followed by concussion, bruise, and abrasion. The psychology of workers is affected.

Nadhim *et al.* (2020) found that the highest impact of a fall from height includes time loss on project execution and risk of reputation of the firm.

2.3.2 An Overview on Some of The Effects of Electrocution as Part of Construction Accidents

The effects of electrocution accidents are dependent on a variety of factors. OSHA (2011) lists some of these factors, including the pathway through the body, amount of current, length of exposure, and whether the skin is wet or dry. The effects of electrocution are cardiac arrest, shock, severe burns, death, nerve damage, muscular contraction, and being thrown away from contact, such as a circuit.

Cardiac arrest: Wu and Li (2024) say that it is the sudden and complete cessation of the heartbeat resulting in ineffective circulation of the blood by the heart. This is triggered by exposure to electrocution hazards on a construction site.

A worker who has suffered a cardiac arrest would not have the capacity to carry on with his duty on site; this could lead to absenteeism, low productivity, and delay in the project delivery.

Shock: Nadhim *et al.* (2023) defines a shock as a sudden or violent mental or emotional disturbance. An electric shock is a sudden burst of electrical energy hitting a person or

animal. When this electrical energy comes in contact with a site worker, it could lead to a shock that can ultimately result in severe injuries.

The implications of this incident on site could be humanitarian, economic and also legal.

Severe burn: Severe burn is a very serious injury caused by heat and electricity; it is also a state of becoming overheated to the point of being unstable.

Death: Death is the loss of life due to exposure to electrical shock. When death occurs on site as a result of an electrical accident, it dampens the morale of workers and may result in a temporary stoppage of work, resulting in a delay.

Nerve damage: The nerve is a bundle of neurons with their connective tissue sheaths, blood vessels and lymphatic. Exposed to an electric shock can cause damage to the nerve (Nadhim *et al.* 2023).

Muscular damage: This is a strong and often painful shortening of the muscles that occurs as a result of being exposed to an electric current.

2.3.3: Understanding the Effects of Building Collapse

Shakil (2019) and Falana and Nouby (2019) identify the various effects of building collapse, among which are:

Damage of plants and equipment: The collapse of a building during construction can damage the construction plant and equipment. This renders plants, tools and equipment unusable, leading to unplanned costs for repairs or to buy new ones, which result in economic implications. Additionally, the loss of life and injuries to workers trapped in the collapse would have serious health implications and may result in legal actions against the employer.

Payment of settlement for injuries and death: Falana and Nouby (2019) declare that when accidents occur on site and a worker is injured or ultimately dies in the process, such as in a structure collapse, compensation is paid to the injured worker and to the family of those who eventually lost their lives as a result of the accident.

Damaged reputation of the employer: The reputation of an employer would be on the line when an accident occurs on site, particularly one that claims the life of a worker. An investigation will be carried out to determine the cause of such an accident. If the employer is at fault, his reputation would be marred, and he could also lose his license to practice.

Disruption of Site Operation: Shakil (2019) asserts that when there is a collapse accident on a construction site, injuries and death and loss of properties and equipment could occur. The resolution process for injured workers and those who have lost their lives is often lengthy. This is primarily due to the time required to conclude investigations, with additional delays arising from any legal proceedings.

Cost of Case Litigation Process: Extra unbudgeted funds are paid to process and settle economic and legal aspects of the effects of accidents. The unbudgeted funds are settlement money paid to treat the injured workers, money paid to the families of workers who have lost their lives and so on.

When there is a collapse accident on a construction site. A collapse accident on a construction site poses a risk to all workers. Ayodeji (2019) found that building are of high economic value, whether for a socio-economic development or developing home dwellings. He noted that the consistent failure of buildings and structures would slow the economic growth of a country.

2.3.4 An Overview on the Effect of Crane Accidents in the Construction Industry

Several authors such as Nurmahamira *et al.* (2019) and Nuruls and Abdul (2018) list the effects of crane accidents, and they include the following: loss of profit, permanent and non-permanent disability, death, injuries, loss of time, and loss of profit.

A *crane accident* can lead equipment damage, loss of life, and injuries to the workers on site. Additionally, it can also result in damage to equipment and plants, regardless of whether the collapse involves parts of the building or the whole building. These may lead to a loss of profit as extra money would be needed to cover up for all that has been destroyed or lost in the accident. A crane accident that results in the death or injuries of

workers will require extra money to be paid to the victims' families and more money would be spent to treat the injured, train new workers, or buy new equipment.

Permanent and Non-permanent Disability: Workers who have been involved in crane accidents stand the risk of permanent disability, such as not being able to walk again or permanent damage to a body part could also lead to temporary disability. This phenomenon could slow down the pace of construction project and have severe health, economic and legal consequences.

Death: A site where a crane accident has occurred and has resulted into the death of the worker involved lowers the morale of the workers, causing low productivity, and may halt the project's progress. Death is the most tragic effect of an accident that not only destroys the enthusiasm of workers on the site but also disrupts the progress of the project. Crane accidents can lead to death. A site where death has been recorded due to a crane accident may have a negative effect on the psychology of the workers, legal actions on the employer, and loss of time, as the project would have to stop either permanently or temporarily.

Injuries: The injuries that occur from crane accidents can either be temporary or permanent. These injuries could lead to permanent or temporary disability as well.

Losses of time: Time, plants, equipment and life—all of these types of losses could be recorded on-site where crane accidents have occurred.

Sabri and Whaid (2018) found that the effects of crane accidents include severe injuries followed by permanent and temporary disability and the risk of death and loss of profit

2.3.5: Effect of Vibrating Tool Hazards

Krajanak (2018) identified the effects of the hazards of vibrating tools to include the following:

Neurological disorder: Neurology is the branch of science that deals with the nervous system and its disorders. The nervous system consists of the brain, nerves, muscles, and the neuromuscular function of the peripheral nervous system. Therefore, neurological

disorder is the disorder or deficiency in the operation of the worker's nervous system, which includes its interaction with the brain.

Disorder of the sensory function/reduction in tactile sensitivity: Tactile is regarded as the sense of touch—tangible perception. Being exposed to vibrating tool for a very long time can reduce the tactile sensitivity of a worker and induce a disorder of the sensory function.

Loss of manual dexterity: Dexterity refers to the skill and ease in performing tasks, especially with the hands. Deficiencies and disorders such as neurological disorders and disorders of the sensory functions can lead to loss of dexterity in working with the hands. These disorders would highly reduce the efficiency of a site worker in performing his task, which could have a negative economic effect on the project.

Neck and Shoulder Pain: The health of a worker who is exposed to the hazards of a vibrating tool for a long period of time is at stake. This situation could result in neck and shoulder pain, which would render him incapable of working on the site.

Cardiovascular disease: These are disorders that involve the heart or blood vessels, for instance, the arteries and veins. Cardiovascular disorder can occur as a result of consistent exposure to vibrating tools. If this occurs, the worker on site is no longer able to perform his duty efficiently and this would negatively impact the progress of the project, because it would slow the pace of construction, which would eventually have economic and legal implications (Krajanak, 2018).

Joint Damage (wrist, elbow, knee): The consistent use of vibrating tools can damage the joints as pressure is exerted on those joints as the tools are being used.

Kranjnak (2018) states that whole body vibration may increase the risk of developing prostate cancer. This may eventually result in death.

2.4: Preventive Measures Against Accident on Construction Site

Many fatal accidents have periodically happened in the construction industry. Various measures, such as applying new construction methods or safety and health management systems, have been applied with the aim of preventing accidents. However, labour accidents in the construction industry still account for a higher percentage of the total

accidents across all industries. Hence, effective new measures for preventing labour accidents are required.

Abdul *et al.* (2008) found that accidents on construction sites are caused by factors such as unsafe equipment, job site conditions, unsafe methods, human elements and management. He further explains that the causes of these accidents on site can be attributed to workers' negligence, failure to obey existing work procedures, working at elevated heights without proper safety equipment, and so on.

Abdul *et al.* (2008) found that accidents on construction sites are caused by factors such as unsafe equipment, job site conditions, unsafe methods, human elements, and management. He further explains that the causes of these accidents on site can be attributed to workers' negligence, failure to obey existing work procedures, working at elevated heights without proper safety equipment, and so on.

Falling object accident: To prevent accidents relating to falling objects, the following factors were identified by Oladele (2014):

Hazard identification: Employers should be able to identify the hazards on site prior to the mobilisation of materials and workers to the site and prepare schemes that would be used to tackle and prevent these accidents.

Safety regulations and strict enforcement: Employers should prepare and distribute safety regulations to all workers, including other stakeholders in the project, and enact strict regulations and penalties for every worker not complying with them.

Personal protective gear: The use of personal protective equipment remains one of the best measures in ensuring construction work-place safety for its workers (Happy, 2022). Safety and personal protective gear should be made available on-site and distributed according to the hazards workers are exposed to on site. All gear and equipment should be kept consistently in excellent condition.

Safety officers: Employers should employ qualified safety officers to ensure that the day-to-day activities on site are carried out in accordance with every safety regulation that has

been put in place. Additionally, they should also be stationed permanently on site, or they could run shifts while work is going on site

Welfare: Employers should ensure that adequate attention is paid to the welfare of all workers on site. Employees must have health insurance to ensure that they are entitled to compensation for any accidental occurrence.

Training: Haslinda *et al.* (2016) found that there is a strong positive relationship between proper training of employees and their safety on construction sites. Intensive training should be given to all workers on site on how to protect themselves from the hazards they are exposed to while working on site, especially at elevated levels.

Language barrier: During training, both local and English languages should be used to train workers. This would solve the issue of the language barrier and grant simple communication between workers, thereby increasing team's productivity and high performance and preventing accidents that could arise from language barriers.

2.4.1 Preventive Measures Against Falls from Heights and Scaffolding Accidents

According to estimates, construction sites account for every third occupational fatality or injury. Also, in comparison to other areas of economic activities, many more violations of regulatory enactments on health and safety are registered in the construction sector (Titas & Jurgita 2013).

Working four feet higher off the ground increases the risk of a worker falling. The hazards workers are exposed to include anything that can cause one to lose balance and fall; most of these falls occur from falling off roofs, platforms, ladders, or scaffoldings (Nurmahamira *et al.* 2019). Preventive factors against this type of accidents include training, the use of PPE, good maintenance, ensuring excellent condition of equipment and tools, qualified workers, and no language barriers.

The risks of falls from height on construction sites can be greatly reduced or eliminated with typical measures such as training, fall protection systems, enforcement of regulations, workplace inspections and operation safety management systems (OSHA, 2014). Rajendran (2019) ranked areas on site with the most frequent fall occurrence. He

found that scaffolding recorded the highest fall, followed by falls from ladders and roofs. He also ranked the causes of the accidents, with the most frequent cause being working at elevated levels with unprotected sides and edges; poor housekeeping was also recorded as one of the most frequent causes of fall accidents.

2.4.2 An Overview on Preventive Measures Against Electrocution Accidents

The major hazard regarding electrical shocks are contact with energised sources, which causes electrical shocks and burns (OSHA, 2011). Workers on construction sites who are exposed to the hazards of electrocution include the following: electricians, power line installers, telecom line installers, roofers, heat and air condition mechanics, foremen, labourers, truck drivers. Xuanwen *et al.* (2017) state further that electrocution is the third leading cause of death among construction workers. Preventive measures are listed below:

- Maintain a safe distance from overhead power.
- Use of a ground fault circuit interrupter [GFCI].
- Inspect extension cords and portable tools for openings, which could lead to the transmission of electric current before use.
- Use of power tools and equipment as instructed by the designer.
- Follow the tag-out or lock-out procedure.
- Use an overhead power line distance warning device for heavy equipment and vehicles such as trucks and cranes.
- Avoid working in the rain until it is safe to return to work in areas where there is close proximity to electricity.

Wang *et al.* (2015) found that the use of PPE like rubber gloves and non-conductive clothing, regular tools inspection and engineering control like surge protection devices are preventive measures that would help mitigate the occurrence of electrical accidents. Basista *et al.* (2018) found that the most important measures to be taken by site workers to prevent the occurrence of electrocution accidents on site involve the use of PPE.

Additionally, this equipment should be personalised to each individual and should have both a certificate of approval and manufacturers guidelines.

2.4.3: Preventive Measures Against Building Collapse

To prevent the occurrence of building collapse, reliability checks should be carried out on every structural design for briefs and design deficiencies that could result in the collapse of the structure. Adequate training must be ensured, certification of the knowledge required should be ensured, and corruption should be avoided (Oluwadare *et al*, 2018)

Preventive measures against building collapse accidents

- All building plans tendered for approval to build must conform with building regulations, as this would tackle the deficiencies in the briefs and design. When designs are submitted to be screened before construction is approved, deficiencies in designs are tackled, which can prevent accidents before they occur on site.
- Construction work should not be carried out without proper building approval to develop. Buildings constructed without government approval should be penalised. Strict enforcement of building laws, which prohibit construction on a site without the proper approval would compel building contractors go follow the correct process to obtain approval to build. This would reduce the issues that could arise from design deficiencies and corruption thereby preventing the occurrence of accident on site.
- Soil bearing capacity should be investigated before the building design is done. This would inform the professionals such as the architects and structural engineers of the capacity of the soil and this would guide them in designing the right building for the right soil bearing capacity and by doing so preventing the issues of collapse that could arise from overloading the soil.
- The proper professionals should be involved at every stage of the construction. Professionals are trained and experienced; involving them in the construction process would ensure, to a high degree, safety from accidents that could arise from employing the services of a non-professional.

- The live load and dead load of the building should be properly calculated by structural engineers to prevent excessive loading, which could result in collapse. When the building is carrying more load, either dead or live load, than it was designed for, can result in the collapse of the building.
- Strict and consistent supervision by professionals should be undertaken seriously by the employer. Zhang *et al.* (2020) found that supervisors behaviour on construction sites has a significant impact on ensuring the safety of their workers on construction sites, noting that constant supervision with the appropriate method of communication could reduce the number of accidents. The site should employ safety personnel who would be present on site at all times to ensure strict adherence to safety regulations and to prevent issues such as corruption; for example, ensuring workers are using the right proportion of aggregate or proper rod size while constructing, as intentional incorrect use of these items for gains can lead to structure collapse.

Ayodeji (2019) found that to prevent the especially at regular intervals of building collapse recognised bodies such as (SON) Standard organisation of Nigeria needs to be more effective in screening and sanitizing building materials that are sold in the country. He further states that all professionals' bodies involved in the construction industry should be more involved in checking the quality of building materials; he also stated that incentive such as good sick pay and a better to salary could be used to motivate construction site workers as this would go a long way in reducing factors that causes collapse in construction.

2.4.4 An Overview on Preventive Measures Against Crane Accidents

Construction activities have recorded significant achievements in the last 20 years as a result of an increase in development activities and the demand from the public. Occupational health and safety issues have become major issues for construction organisations, financial and human losses have been suffered in the industry as a result of poor safety management (Sahil, 2021).

For any industry to be successful it has to be safe, reliable and sustainable in its operations; the hazards of the industry have to be identified and assessed for associated rules and brought to a tolerable or very reduced level (Devdatt *et al.*, 2018).

Measures to be taken to prevent accidents relating to cranes begin with the investigation into their causes and analysing these causes to provide solutions that would reduce the hazards workers are exposed to while working with cranes on construction sites (Radov and Ivanov, 2020).

Communication barrier: Language barriers should be avoided. This could be done by employing teams who speak the same language or training the whole team in the same language.

Licensed and qualified operators: It is imperative that operators should be licensed, and well situated for the job. Operators should also be organised and careful, as they would be held accountable for their actions if they do not abide by the regulations, for example, if found under the influence of alcohol before operating a crane.

Constant supervision: Proper and constant supervision would go a long way in preventing crane accidents. Supervisory staff should be stationed permanently on site, and they could run shifts to ensure constant supervision of work on site.

Sign boards and communication boards: They should be well situated where communication with significant operation cannot be obstructed or impaired.

Environmental factor: Working in hazardous weather conditions could lead to poor visibility; working in a tight and disorganized environment in a congested work area with no proper plan of work creates confusion, which could result in accidents. Having a planned and sequenced process to working on site, where the working area is properly organized and well-spaced for work, would go a long way in preventing environmental factors that could result in crane accidents.

Safety management: The use of protective gear for all site workers should be made mandatory. Employers should make provision for safety gear for all persons working on-site; cranes should be properly maintained to ensure they are in excellent condition. The

cranes should also be properly inspected before use to avoid problems like track and buffer failure.

Overloading: This should be avoided by maintaining the manufacturer's guidelines regarding the load-bearing capacity of the crane.

Sabri and Wahid (2018) found that providing safety and health training, having an awareness of the hazards associated with the job being carried out and employing the service of professional who are able to manage and control those hazards to be the most effective measures against crane accident.

2.4.5 An Overview on Preventive Measures Against Vibrating Tool Hazards

Edward and Holt (2005) state that identifying and assessing vibration hazards and exposure levels, deciding who is at risk of these vibrations and providing the appropriate information and training to employees is the responsibility of the employers on construction sites and would assist in preventing vibrating tool hazards. The list below presents factors that should be considered to reduce vibration tools hazards:

- Selecting or buying a low-vibrating tool, when there is an option to work with a tool that has a lower vibration frequency would prevent the exposure to vibration.
- Maintaining the tools properly, a proper maintenance scheme would keep the tools in good shape, and this could reduce the degree of vibration as some tools tend to vibrate more when they are not in good condition.
- Using the tools in a way such that the potential vibration is reduced by maintaining proper grip; the correct hand-held technique is shutting off at the right time.
- Using protective clothing and gloves to maintain the flow of blood and absorb most of the vibrations.
- Training workers on how to use these tools and giving strict, instructions when a worker lacks the proper training on how to work with a tool or does not follow the proper instructions set by the manufacturer. These workers may use the tools in a way that would expose him or her to more vibrations.

- Driving surfaces should be regular and even to avoid vibrations caused by driving on uneven surfaces; driving practice would help in preventing whole body vibration, as the worker or driver would have gotten used to how to avoid these vibrations.
- Proper maintenance would help maintain these tools in good condition and thereby prevent vibration that could have occurred as a result of poor maintenance.
- Seats should have proper vibration absorption materials so as to reduce the impact of these vibrations in the case of a vibrating vehicle (Edward and Holt, 2005).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology employed in collecting and analysing data in order to meet the study's aim and objectives and provide answers to the research questions. It includes the research design, the methods and tools of data collection, the reliability and validity of the methods of study, and the limitations encountered.

3.2 Research Methodology

Research methodology is an approach or means of structuring and undertaking advanced study investigations that are targeted at identifying variables and their relationship to one another. According to Teddlie and Tashakkori (2009), the term 'methodology' refers to a logic of inquiry or the general philosophical approach to research. Anugwo (2017), citing Leedy and Ormrod (2013), states that research methodology involves three processes, namely, data collection, data analyses and interpretation, which are aimed at providing a framework to understand the nature of the study's phenomenon. Anugwo (2017) further claims that research methodology can be considered as the critical process of undertaking and asking and answering advanced study questions in the real world. This can be done through a questionnaire, interview, experiment and other different methods. According to Oberiri (2017), research methodology is the holistic steps a researcher employs in embarking on an advanced research study. In addition, Leedy and Ormrod (2014) affirm that research methodology is a general approach a researcher applies in investigating a research study. To some extent, this approach dictates the appropriate research method and tools that the research adopts, as well as a framework that provides the blueprint of the study from conception to completion. According to Kagioglou *et al.* (1989) a research methodological framework primarily guides the relationship between three layers of the research methodology, namely research philosophy, research design, and research methods, and these layers determine the choice of techniques to be adopted for data collection and analysis in a given research study.

3.3 Research Philosophy

It is of paramount importance to understand the philosophical background of an advanced research undertaking. The research philosophy answers the question of how knowledge is generated; it expands on the nature of that knowledge and further explores how it is developed. Saunders *et al.* (2023) proposed that the understanding of the research philosophy is dependent on the consideration of three types of assumptions, which are epistemology, axiology, and ontology. The three worldviews provide a framework for the philosophies that exist in the first layer of the research onion, which comprise positivism, interpretivism, pragmatism, postmodernism, and critical realism (Saunders *et al.*, 2019). This study accents the pragmatism philosophy. According to Saunders *et al.* (2023), pragmatism refers to viewing research through the constructivism and objectivism perspectives or one of the two perceptions. Pragmatism philosophy enabled the researcher to understand the context in which construction workers and the types of health and safety (H&S) risks they are exposed to on construction sites. This understanding allowed the researcher to develop a strategy that would enhance effective implementation of H&S best practices in mitigating construction site accidents and fatalities. Regarding the research aim and the hypotheses stated, the study assumes a positivist philosophy. According to Saunders, Lewis, and Thornhill (2019), positivism explains gauging the state of accepted knowledge about the world. In positivism, numerical data collection and analysis are key components of quantitative research. This study adopted the positivism stance.

3.4 Research Design

Designs in research are strategies that span decisions from broad assumptions to detailed methods of data collection and analysis (Creswell 2009 cited in Anugwo 2017). Anugwo (2017) cited Leedy and Ormrod (2013) claiming that research design is a general strategy for dealing with the identified research problem (see section 1.2) through a holistic research framework from inception to completion. Anugwo (2017) claimed that research design capacitates researchers to effectively decide and choose the most appropriate research method based on nature and type of investigation the study requires. Anugwo (2017) further cited Leedy and Ormrod (2013), affirming that research

design provides a framework to systematically investigate and resolve an identified research problem by providing the researcher with an explicit strategy. The problem identified in this research (Sections 1.2.1–1.2.4) is that “the past and recent records of construction site accidents and occupational injuries in KwaZulu-Natal construction industry are an indication of effective management strategy for the prevention of construction fatal accidents is not well-understood by practitioners”. The research design should therefore provide a framework for data collection and analysis that leads to the resolution of this problem. Thus, research design plays a crucial role in shaping data collection and analysis approaches (Anugwo, 2017). In addition, the methodology encompasses data collection methods, research design and data analysis techniques. The study followed a quantitative approach for data collection with a self-designed questionnaire to collect both quantitative data, which included closed-ended questions. . Sekaran and Bougie (2016), claim that validity testing, also known as survey instrument authenticity in quantitative research, assesses the degree to which a survey instrument measures what it is designed to measure.

3.5 The Research Methods

Anugwo (2017) cited Kinash (2008:), claiming that research methods are the techniques and principles used in conducting an advanced and scientific research investigation. The body of knowledge that utilizes these methods is referred to as the methodology. Research methods are parts of methodology that are used to gather and analyze data through a systematic approach to scientific thinking and research while developing new knowledge (Anugwo, 2017). Anugwo (2017) further affirms that in the advanced research realm, there are two cardinal types of methods in research, which are basically the qualitative and quantitative methods. However, the combination of these two methods in a single research is referred to as the mixed research method.

3.5.1 Quantitative Research

Anugwo (2017) claims that the quantitative research approach utilises quantitative methods for data collection, analysis and testing hypotheses. Leedy and Ormrod (2010) state that quantitative research method primarily focuses on eliciting factual data and studying the relationships between them. Thus, data are usually in the form of numbers

that can be quantified and summarised. The analysis of data collected produces empirical results and conclusions that are drawn from the observation of these results based on theory and review of related literature (Anugwo, 2017). Hennink, Hutter and Bailey (2011) supported the view of Anugwo (2017) that the quantitative research approach focuses on and depicts numerical data and employs statistical analysis to explore cause-and-effect relationships between variables. Thus, this technique ultimately emphasises objectivity and generalisability, making it suitable for testing hypotheses and drawing conclusions based on empirical evidence (Leedy & Ormrod, 2010).

In addition, Blaikie (2010) affirms that there are different levels at which quantitative research could measure its data empirically, and these include nominal, ordinal, interval and ratio levels. The nominal scale is commonly used because values can be assigned to objects, people and events in terms of the characteristics they share (Blaikie, 2010). Nieuwenhuis (2007) agrees that quantitative research methods allow for precise measurement and quantification of variables, enabling researchers to analyse data objectively and draw statistically sound conclusions. By employing standardised instruments such as surveys or experiments, researchers can collect consistent, comparable data across different contexts, enhancing the reliability and validity of their findings (Leedy & Ormrod, 2010). Overall, quantitative research is appropriate for investigating complex phenomena such as appropriate and effective prevention strategies to mitigate incessant construction site accidents and fatalities in South Africa. By systematically testing hypotheses and analysing numerical data, researchers and industry practitioners would gain strategic and valuable insights into the factors to improve H&S best practices in South African construction sites.

3.5.2 Qualitative Research

Anugwo (2017) cited Marshall and Rossman (2011), claiming that qualitative research employs a broad technique for investigating social phenomena. Qualitative research, thus, denotes the qualities of real-world phenomena within the context of the social reality of research participants. In broad terms, Marshall and Rossman (2011) clearly emphasise that qualitative research methods are nature-based research that produces contextual findings. Thus, these findings are not obtained from statistical procedures or other quantitative means, such as themes, contextual opinions and the sharing of personal

experiences related to the subject matter under investigation (Marshall and Rossman, 2011; Anugwo, 2017). Leedy and Ormrod (2010) believe that qualitative research approaches delve into the nuances and complexities of real-world phenomena, thus prioritising depth of understanding over breadth of information. Therefore, a qualitative research approach is usually most appropriate for investigating the multifaceted nature of a given subject matter, primarily empowering researchers to explore the contextual factors and social dynamics. According to Leedy and Ormrod (2010), the critical strength of qualitative research lies in its ability to capture the rich, nuanced experiences and perspectives of individuals within their natural environments. Thus, research techniques such as in-depth interviews, focus groups, case studies, ethnographies and content analyses offer researchers a range of tools for exploring the subject matter under investigation.

3.6 Chosen Research Methodology for the Study

This research study employed a quantitative approach in order to systematically elicit and analyse the collected data in statistical figures. Thus, this study employed a structured questionnaire of closed-ended questions to collect quantitative data from the research respondents. The questionnaire comprised Likert scale questions, ensuring comprehensive data collection (Rene & Adonisi, 2009). While quantitative research aimed at numerical analysis to establish relationships between variables on key factors contributing to the incessant construction site accidents and fatalities in the KwaZulu-Natal construction industry.

3.7 Data Collection

The data collection process involved the dispatching of the questionnaire using electronic modes such as personal administering through emails, and Google Forms links were emailed after being given the ethics clearance and gatekeeper's permit from DUT's Institutional Research Ethics Committee (IREC) and the South African Council for the Project and Construction Management Professions (SACPCMP), respectively. Thus, through the education administrator of the SACPCMP, the questionnaire in Google Forms link were distributed to all the relevant members for completion at their convenience. Reliable professionals in the industry and at project sites were contacted, including

contractors, project supervisors and managers, who were contacted via email. and all of these forms were collected and complied after being completed, returned and found valid. Thereafter, all the data collected through the research questionnaires were further exported to Microsoft Excel for coding.

3.7.1 Primary Data

Primary data is original and unique data that is personally collected by the researcher from a source according to a given study's requirements. Ravrinda (2020) states that it is the data collected by the investigator for a specific purpose. Data gathered by *finding out first-hand the attitudes* of a community towards health services, ascertaining the health needs of a community, evaluating a social program, determining the job satisfaction of the employees of an organisation, and ascertaining the quality of service provided by a worker are examples of primary data. Data that has been collected from first-hand experience and has not been published yet is more reliable, authentic and objective and is known as primary data. Primary data has not been changed or altered by human beings; therefore, its validity is greater than secondary data.

Importance of primary data: In statistical surveys it is necessary to get information from primary sources and work on primary data. Research can be conducted without secondary data, but research based only on secondary data is the least reliable and may have biases because secondary data has already been manipulated by human beings. Such sources are old, and secondly, they may contain limited information and can be misleading and biased (Syed, 2018). Thus, primary data will be collected using a research questionnaire. The data collection instrument to be used in this study would comprise online surveys using Google Forms and online-based questionnaires. The research would also make use of paper-based questionnaires through mail or physical or hand delivery, as the case may be. The questionnaires would take between 10 and 15 minutes to complete.

The respondent will respond to the items to be recorded on a 5-point scale, where 1 represents total disagreement and 5 represents total agreement, and reliability, along with validity issues, would also be assessed.

$$MIS = (n) + 2n_2 + 3n_3 + 4n_4 + 5n_5$$

Where

N1 is the number of respondents who strictly disagree

N2 is the number of respondents who disagree

N3 is the number of respondents who are neutral

N4 is the number of respondents who agree

N5 is the number of respondents who strongly agree

N is the total number of respondents.

3.7.2 Secondary Data

Data collected from a source that has already been published in any form is called secondary data. The review of literature in any research is based on secondary data. Common sources of secondary data for social science include censuses, historical data/records, published articles, textbooks, organisational records and data collected through qualitative methodologies or qualitative research. Secondary data is essential since it is impossible to conduct a new survey that can adequately capture past change and/or developments. Sources of Secondary Data: The following are some ways of collecting secondary data (Syed, 2018). The various sources to elicit research secondary data are from textbooks, historical records, biographies, newspapers, published censuses or other statistical data, databases/archives, internet articles, research articles by other researchers (journals), and journal and conference proceeding databases.

3.8 Questionnaire Development

This phase of the research discusses the process of collecting data and utilizing the research instrument from the field by employing a well-structured questionnaire. Sekaran and Bougie (2016) state that this process of data collection is a very critical part of the whole research towards realising the aim and objectives of a research study. This study collected data using a questionnaire survey, which was deemed most suitable for collecting data from professionals within the built environment in the South African

construction industry via the SACPCMP. Thus, this study administered a questionnaire survey as a data collection instrument among members of SACPCMP through emails and other digital forms (Google Forms). The questionnaire was designed with Google Forms and links were emailed to professionals through the SACPCMP administrator/secretariat portal.

3.8.1 Questionnaire Survey Instrument

In the process of designing the questionnaire for this study, ordinal and categorical scales were used. Complex terminologies that could confuse respondents were avoided, while simple terms were used through the close-ended nature of questions, as they grant the respondents the opportunity to select an option to rank the level of importance of factors that influence or cause, have effects, or have strategies to mitigate construction site accidents in the South African construction industry. Thus, the respondents were asked questions to reflect their demographic and personal information with regard to their highest educational background, professional affiliation and qualification, and also their years of experience. The study questionnaire made use of a 5-point Likert scale resulting from its high reliability coefficients and high likelihood of responses, which adequately reflects the opinions being focused on (Zikmund, 2000). Thus, the questionnaire was a pre-designed set of questions that sought to collect opinions, reactions and responses from correspondents of research participants (Sekaran and Baigle, 2016).

3.9 Target Population

Population refers to the entire group of individuals who are relevant to this study (Neuman, 2006). The target population for this study involves relevant professionals from SACPCMP members. Creswell (2013), states that a research study should note the size of the targeted population and utilise it as a means of identifying who makes up the population and its potential sampling. For the study SACPCMP where the only sample (see figure 1) used while other workers on construction site and safety officers were not included in the sample that were investigated is because the SACPCMP were the only body of professionals who have the gate keeper's permission.

The composition of the sector sample frame is represented in the table below.

Table 1 The SACPCMP Registered Members' Population Size

Professional Body	Sector/ Professional Category	Total Number of Population
SACPCMP	Construction Manager and Construction Project Managers - Registered professionals	2904

Source: SACPCMP (2024)

3.9.1 Research Population Sample Size

Sampling is a process of observing a part of the research process in order to gather information about the whole nature of the population, which is an almost instinctive human act (Corbetta, 2003). In order to glean information effectively, the total general population should be reduced into a smaller sample, and the most appropriate sampling technique should be selected accordingly. According to Sekaran and Bougie (2016), the sample refers to the subsection (individuals or institutions) of the population that is relevant to the study and is considered for data collection. There are various sampling methods and techniques involved in the process of research population sampling, including the following:

Random sampling: This technique of sampling allows the sample to be chosen by a simple random selection where every member of the population has an equal chance of being selected

Stratified sampling: Aiyetan (2017) states that this technique of sampling occurs in a population that consists of different strata or groups. The researcher selects samples from one of the strata or groups equally to ensure equal representation.

Systematic sampling: This is a sampling technique that allows researchers to select a sample size in sequence; a list of units is made from a population of interest; for example, every tenth unit on the list is then selected and joined with a sample list.

Cluster sampling: This type of sampling sub-divides an expansive area into a smaller unit (Aiyetan, 2012); the clusters must be as similar to one another as possible, with each cluster containing an equally heterogeneous mix of individuals.

According to Aiyetan (2012), the following guidelines should be followed for selecting a sample size.

- For a small population with fewer than 100 people, or other units, sampling the entire population is not necessary.
- For a population size around 500, 50% of the entire population should be sampled.
- With a population size around 1500, 20% of the entire population should be sampled.
- With population of about 5000, a population size of about 400 would be adequate.

Hamed (2017) declares that in order to generalise a random sample and avoid sample errors or biases, a random sample needs to be of adequate size; what is adequate depends on several issues that often confuse people doing surveys for the first time. This is because the absolute size of the sample, how well it fits the complexity of the population, the aim of the research and the statistical manipulation that will be used in data analysis are more important than the percentage of the population that is sampled. He further states that larger sample sizes in the research population reduce the sampling error. Several statistical formulas are available for determining sample size. Additionally, there are numerous approaches that incorporate a number of different formulas for calculating the sample size for categorical data.

$$N = P(100-p) Z^2/E$$

N= the required sample size

P= Percentage occurrence the state or condition

E= the percentage of maximum error required

Z= the value corresponding to level of confidence require

According to Hamed (2017), to generalise from a random sample and minimise sample error biases, the random sample must be of suitable size, which depends on numerous factors that frequently mislead persons doing surveys for the first time. The absolute size of the sample is more important since it is selected relative to the complexity of the population, the aim of the research, and the statistical tools that would be used in data analysis. He also states that larger sample sizes of research populations reduce sampling error, and there are several statistical formulas that are available for determining sample size and estimating the sample size of a population.

One such formula is provided as follows:

$$n = N/[1 + N(e^2)]$$

Where n = sample size, N = Number of target population, and e = precision/error limit = 0.05

The total population of registered professionals in SACPCMP is 2904. Applying the formula, the sample size is 351 for all of South Africa. However, this study focused on professionals within the KwaZulu-Natal Province, and based on that, a purposive sampling technique was used, which had a population sample size of 100, that is, 100 questionnaires were distributed, and 65 questionnaires were returned and valid. Therefore, a purposive sampling approach was adopted based on the nature of the study (localised KwaZulu-Natal), and complexity of distributing among 351 professionals, as the construction industry is notorious in participating in research studies due the pressure to deliver project within timeframe. Thus, the SPSS statistical tool was used for data analysis.

3.10 Data Analysis Process

All completely filled, returned and valid questionnaires were screened, sorted, and statistically processed. Thus, the statistical analysis tools consideration was carried out to decide between parametric and non-parametric statistical tests and measured based on the choices made by research respondents. Thus, the type and nature of test, majorly depends on the level of measurement achieved in the study and the type of variable (Kothari, 2004). In this study. the collected data was first elicited, harnessed, coded and

fed into statistical package for social science (SPSS) software. Thereafter, the collected data were further analysed via descriptive and inferential statistics. A larger t – value shows that the difference between group means is greater than the pooled standard error, indicating a more significant difference between the groups (Aiyetan, 2011).

In nutshell, the obtained primary data, elicited from the respondents, were further processed, whilst data analysis method used in this study, comprises of inferential and descriptive statistics. Thus, SPSS, a computer program, was used for analysing data pertaining to social phenomena as to analyse the quantitative data that was gathered through the usage of the survey questionnaire in this study. The Statistical Package for Social Sciences (SPSS) version 27 software was used to code, amend, and record the information that had been gathered from the respondents. Following importation, it was changed into a format that could be used for analysis in the Microsoft Excel software program. Using the SPSS computer program, both descriptive and inferential statistics were examined. The advantage of utilizing SPSS is that multivariate analysis can be obtained. It also makes it possible to quickly score and analyse quantitative data. Tables and graphs were created to represent the analysed data for ease of interpretation.

3.10.1 Descriptive statistics

Descriptive statistics involve means (M) and mean scores (MSs). They are used to interpret the data that has been obtained and processed from the research respondents. Montgomery and Runger (2007) describe the mean as a measure chosen such that the sum of deviations from it is zero. The MS is obtained by allocating numerical values to respondents' ratings of factors, which can be, for example, very high (5 points), high (4 points), moderate (3 points), low (2 points), and very low (1 point). The mean score (MS) for each factor is then calculated using the following equation:

$$MS = \sum \frac{(fx_s)}{N} \quad 1 \leq MS \leq 5 \dots\dots\dots(i)$$

Where: MS = mean score

N = the total number of responses concerning that factor

S = the score given to each factor by the respondents and ranges depending on the ordinal scale in use (1–5).

F = the frequency of respondents rating (1–5) for each factor.

In order to test for any agreement in the ranking of the individual factors between various groups of variables, the t-test was used to test the postulated hypothesis at a 5% level of significance. However, there are three ways to present the statistical data: textually, in tabular form, and graphically. When data is presented using a textual technique, it is usually mentioned as simple text, usually contained in a paragraph. In tabulation, tables are required to show the results; however, in graphical presenting analysis, graphs are required (De Vaus, 2014, 207). Descriptive statistics are used to summarise patterns in respondents' replies to a question contained in the questionnaire surveys. Thus, descriptive statistics were used to determine the level of construction site accidents and their impact as a result of fatality within South African construction industry, especially in KwaZulu-Natal province.

3. 10.2 Inferential Statistics

According to Saunders, Lewis, and Thornhill (2019), inferential statistics make inferences about the population from the selected sample. It makes it possible to estimate the likelihood of the result based on the sample size and the extent to which chance may have affected the results. Inferential statistics using linear regression analysis were used. This statistical method was intended to establish the relationship between causes of construction site accidents and fatalities, and their resultant effects on construction projects and workers. Inferential statistics were used to process and analyse summated scores of the responses from the primary research respondents to reflect the actual support for the study's objectives and subject matter under investigation. Thus, considering "unsure" responses as a legitimate response. It was decided that placing this response at the midpoint of the like rate scale will give it value among the numerators and denominators in the midpoint of the scale could be justified as the respondents are neither considered as certain or uncertain nor negative or positive. It could be assumed that they are neutral.

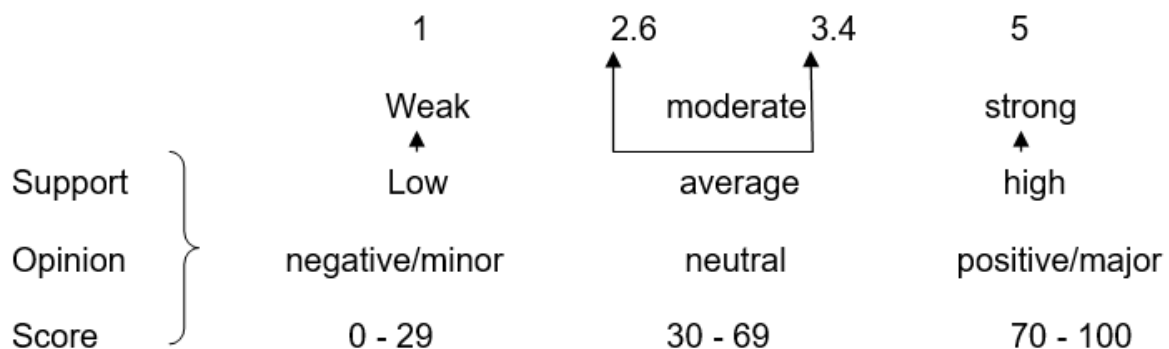


Figure 1 Scoring of responses on the Likert scale

Source: Gravetter and Wallnau (2008)

Figure 1. is an example of how the summated score of one of the sub-problems responses was calculated.

$$\begin{aligned}
 & [(4 \text{ responses} \times 1) + (4 \text{ responses} \times 2) + [(4 \text{ responses} \times 3) + (3 \text{ responses} \times 4) + \\
 & (3 \text{ responses} \times 5) + (3 \text{ responses} \times 6) + (5 \text{ responses} \times 7) + (5 \text{ responses} \times 8) + \\
 & (3 \text{ responses} \times 9) + (2 \text{ responses} \times 10) + (4 \text{ responses} \times 11) + (3 \text{ responses} \times 12) + \\
 & (2 \text{ responses} \times 13) + (0 \text{ unsure responses} \times 2.5)]
 \end{aligned}$$

$$41 \text{ réponses} \times 13 = 56\%$$

By comparing this score to the categories of scoring responses in Figure 1, it is confirmed that it will fit into the neutral category. Thus, the built environment practitioners may be deemed to be neutral regarding the causes, effects and prevention of naturally caused accidents such as the collapse of a structure. In addition, statistical inference techniques enable judgements, conclusions, estimations and predictions to be made from data collected. Given that proof of an acceptable level of consistency is required to make sense of the finding, Gravetter and Wallnau (2008) state that the percentage variance to speed

up interpretation of R^2 or r^2 , or a range for practical significance, was suggested regarding the effect of different values on the consistency of responses.

Table 2 Interpretation of R^2 or r^2 for practical significance

Range	Effect
< 0.099	No effect
.01 to .089	Weak effect
.09 to .249	Moderate effect
.25 >	Strong effect

Source: Gravetter and Wallnau (2008)

Table 3 Interpretation of Cronbach's alpha values

Values	Reliability
< .5	Poor
.5 to .7	Sufficient
> .7	Good

Source: Nunally (1978)

Table 3 shows, Cronbach's alpha coefficient is greater than the recommended minimum for reliability (Nunally 1978) was observed for values. Nunally (1978) noted that in the early stages of research, reliability of 50 to 60 is sufficient for this study; reliability of 60 was used as a cut-off point value to reflect. Table 2, shows the reliability of each individual measuring instrument was also taken into consideration. Thus, the internal reliability of the measures relating to the indices all exceeded this cut-off point and are considered acceptable.

3. 10.3 Assessing Statistical Significance

A factor loading is used to represent the correlation between an original variable and its factors. In arriving at or determining a significant level for this interpretation of loading an approach similar to determining the statistical significance of correlation coefficients could be considered. Factor loading and sample size needed for significance are presented in Table 4.

Table 4 Significant factor loadings based on sample size

Factor loadings	Sample size needed for significance
.30	350
.35	250
.40	200
.45	150
.50	120
.55	100
.60	85
.65	70
.70	60
.75	50

Source: (Hair *et al.*, 2004).

A T-test is a method that permits us to compare the average values of the two sets of data and determine whether they came from the same population. For example, if we were to take a sample of students from class A and another sample of students from class B, we would not expect them to have the same mean and standard deviation (Beer, Brown and Hayes, 2021).

T-test formula

The formula shown below represents the two-sample t-test (a.k.a. the Student's t-test).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Interpretation of the T-test formula: t represents the t-value, $\bar{x}_1$ and $\bar{x}_2$ are the means of the two compared groups, s^2 is the pooled standard error of the two groups, and n_1 and n_2 are the number of observations in each of the groups.

A bigger t-value shows that the difference between group means is greater than the pooled standard error, indicating a more significant difference between the groups (Aiyetan, 2011).

The null hypothesis (H_0) is that there is no significant mean difference between male and female GPA scores. The alternate hypothesis (H_a) is that there is a significant mean difference between male and female GPA scores.

Confidence interval: Confidence intervals measure the degree of uncertainty or certainty in a sampling method; they range in probability limits, with the most frequent ranging between 95% and 99% confidence levels. These confidence level tests are carried out using statistical methods, such as the T-test. A 99% confidence interval indicates that the sample population mean is very likely to range between 2.92 and 5.62 with an acceptable p value of 0.0001.

3.10.4 The Study Validity and Reliability

Saunders, Lewis, and Thornhill (2019) state that research validity and reliability are crucial for assessing the caliber of quantitative social science research. Li (2014) affirms that ensuring the measured outcomes are used appropriately is crucial for maintaining validity particularly when gauging the major causes of construction site accidents and fatalities. The aim of this study is to assess the reliability and construct validity of the data on

construction site accidents and fatalities, as well as their impact on construction site accidents and fatalities, as well as their resultant effects on construction projects and workers. Thus, this study ensured that the reliability and validity of the questionnaire used to collect data. Sekaran and Bougie (2016), claim that validity testing, also known as survey instrument authenticity in quantitative research, assesses the degree to which a survey instrument measures what it is designed to measure. There are three different kinds of validity assessments: face, construct, and content. All of these tests provided the degree of survey instrument validity. The content validity of the measuring tool used was addressed by ensuring that the question content was in line with the objectives of this study and the literature. A statistician and the construction practitioners piloted the questionnaire to address face validity. A pilot study is essential for enhancing the quality of the research instrument and the data overall (Creswell, 2016). Prior to gathering data for the primary study, a smaller sample participating in a pilot project was given the questionnaire that was not utilised in the actual research. To ensure the clarity of the survey instrument for this study, a pilot study was carried out accordingly, which assisted in reducing potential bias and enhancing the questionnaire's quality. Thus, reliability is the accuracy or consistency with which an instrument evaluates the trait it is meant to measure (Creswell and Creswell, 2018). If a study and its findings are reliable, then the same results would be obtained if the study were to be repeated by other researchers employing the same methods. To determine the extent of the scale's consistency, based on the data, a reliability analysis using the Cronbach Alpha coefficient was established. It is a measurement that illustrates how consistently a research tool assesses a specific performance or behaviour. According to Maree (2020), the value may range between 0 and 1. This study adopted an internal reliability of 0.80.

3.11 Ethical Considerations

The researcher's observations on the ethical issues are detailed in the parts that follow. Smit (2012) states that ethical issues are deemed relevant during three major phases of the study for respondents: the administration, questionnaire collecting, and respondent selection. The informed consent of the respondents was used to perform the study. The study's goal and the methods utilised to use the data were clearly disclosed in the letter

that was attached to the questionnaire. In addition, the cover letter made clear that taking part in the study was optional, and participants can stop participating at any given time without incurring a loss in any form. The study aims and objectives were clearly explained in the cover letter accompanying the questionnaire. This study strictly ensured the anonymity and confidentiality of the research respondents and their organizations by maintaining and treating all the data in coded form. The protocol of this study ensured that the respondents were anonymous, and their feedback was confidential (Sekaran & Bougie, 2016). In addition, the researcher ensured the literature was properly acknowledged and referenced. More so, the respondents responded in the research questionnaire, which was treated confidentially and used for academic purpose only. It was also the respondents' right not to answer any question that they deemed inappropriate without any loss, harm or intimidation. This study followed the Durban University of Technology, Institutional Research Ethics Committee (DUT-IREC) protocol by submitting the following documents, such as research proposal (PG2a) through the department to the faculty and then to DUT-IREC), with informed consent, the research ethics checklist, the cover letter, the survey questionnaire and the draft gatekeeper's permit. The study obtained DUT-IREC's ethical clearance and as well as gatekeepers permit from the South African Council for the Project and Construction Management Professions (SACPCMP), before the study commenced data collection process.

3.11.1 Study Response Rate

Based on purposive sampling method adopted in this study, a sample size of 100 SACPCMP professionals was selected to respond to issues of construction site accidents within the KwaZulu-Natal construction sector. Consequently, 100 questionnaires were distributed among the SACPCMP professionals based on the purposive sampling technique, and only 65 questionnaires were returned, yielding a 65% response rate. All 65 returned questionnaires were determined to be valid. This response rate was reasonable and more than adequate for data reporting and analysis for this study.

3.11.2 Ethics and the Researcher's Responsibility

Research subjects are more likely to participate in studies that promise them anonymity and confidentiality. Thus, in this study, the researcher was able to build trusting relationships with respondents and win their confidence, according to Sekaran and

Bougie (2016: 321), which has an impact on how credible a research study is perceived by those who participated in it. The protocol of this study ensured that the respondents were anonymous, and their feedback was confidential.

3.12 Chapter Conclusive Remark

This chapter extensively discussed, presented and clearly justified the research methods, approaches and design adopted in the study, as well as the ethical considerations observed. The methods used in this study for data collection, analysis, validity, and reliability were then presented. Thus, despite limitations, the chosen methodology facilitated comprehensive data collection and analysis, laying the groundwork for the subsequent chapters' findings and discussions.

CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the data analysis from data elicited from respondents via the questionnaire, which was designed based on the objectives of the study.

(1) To identify and assess the causes of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry.

(2) To assess the resultant effect of construction site accidents and occupational injuries among workers in the KwaZulu-Natal construction industry.

(3) To assess and recommend strategies that would assist in mitigating construction site accidents and occupational injuries in KwaZulu-Natal's construction industry. Thus, the data analysis and research findings were presented and discussed in tables and figures while interpretation was given based on the information from the tables and figures.

4.2 Response to Questionnaire and Data Analysis

This section presents the data analysis elicited from the built environment professionals within the SACPCMP and the analysis of the results and findings. The main section of this chapter presents the personal and professional details of the respondents, and the second aspect involves key issues in line with the aim and objectives of the study within the subject matter under investigation.

4.2.1 Response Rate to Questionnaire Based on Gender Profile

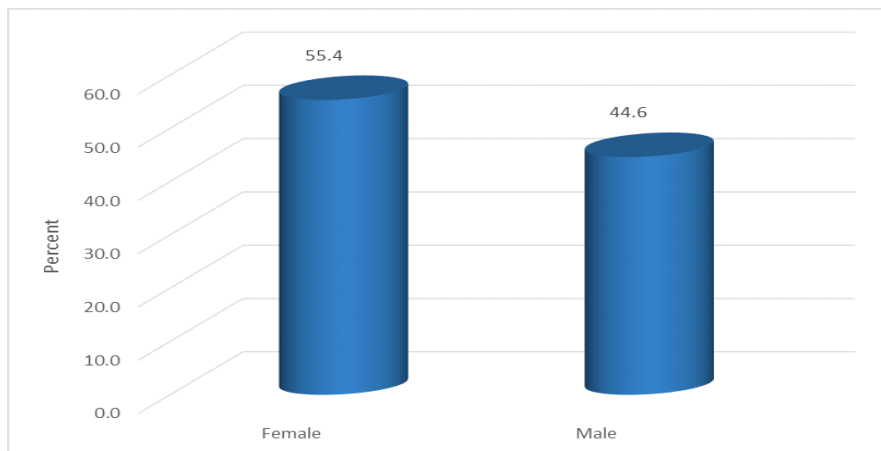


Figure 2 Respondents' response rated and gender profile

Source: Researcher' construct (2024)

In Figure 2, Out of the 351 questionnaires distributed based on the population sample size, a total of 65 respondents filled and returned questionnaires that was deemed valid and relevant. Thus, this study recorded that the gender distribution shows a higher proportion of females: 36 (55.4%) compared to males: 29 (44.6%). The p-value of 0.280 indicates that there is no statistically significant difference between the proportions of males and females in the sample. This suggests that the gender distribution observed could be due to random variation rather than a true difference in the population.

4.2.2 Response Rate Based on Respondents' Qualifications

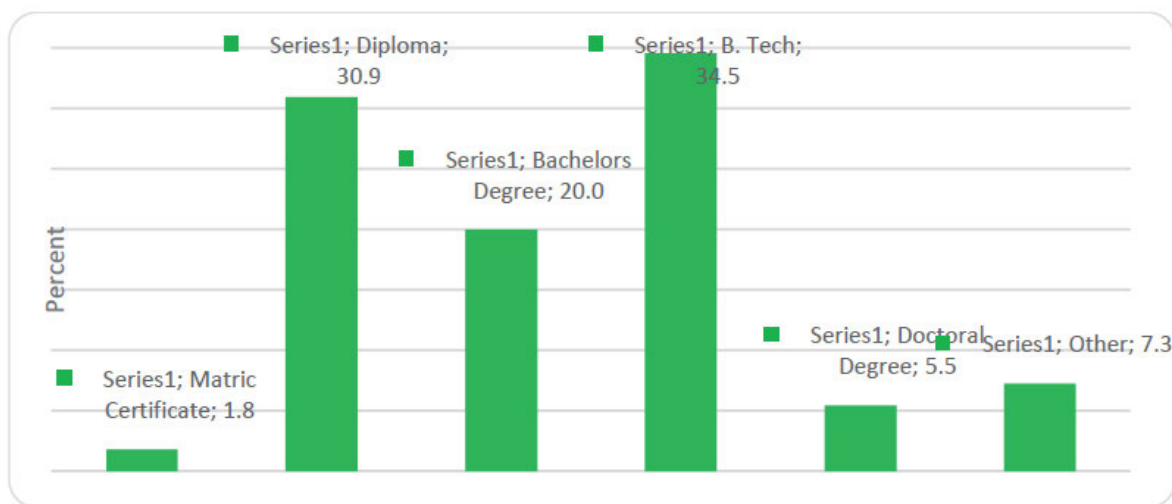


Figure 3 Respondents Highest Qualifications

Source: Researcher' construct (2024)

Figure 3, indicated the majority of individuals have pursued further education beyond the matric certificate, with diplomas, B. Tech, and bachelor's degrees being the most common levels of education. The low p-value (< 0.001) indicates a statistically significant difference in the frequency distribution of educational attainment among the surveyed individuals. The trends highlight a high prevalence of technical and vocational education (diploma and B. Tech) compared to higher academic qualifications (bachelor's and doctoral degrees).

4.2.4 Response Rate Based on Respondents' Status in their Organisation

The average mean experience of respondents

Mean: 8.83

Standard Deviation: 7.62

This section 4.2.4 indicated that, on average, individuals have 8.83 years of experience. The standard deviation of 7.62 years indicates the variation or dispersion of the experience years from the mean, suggesting that the experience levels among individuals vary quite significantly.

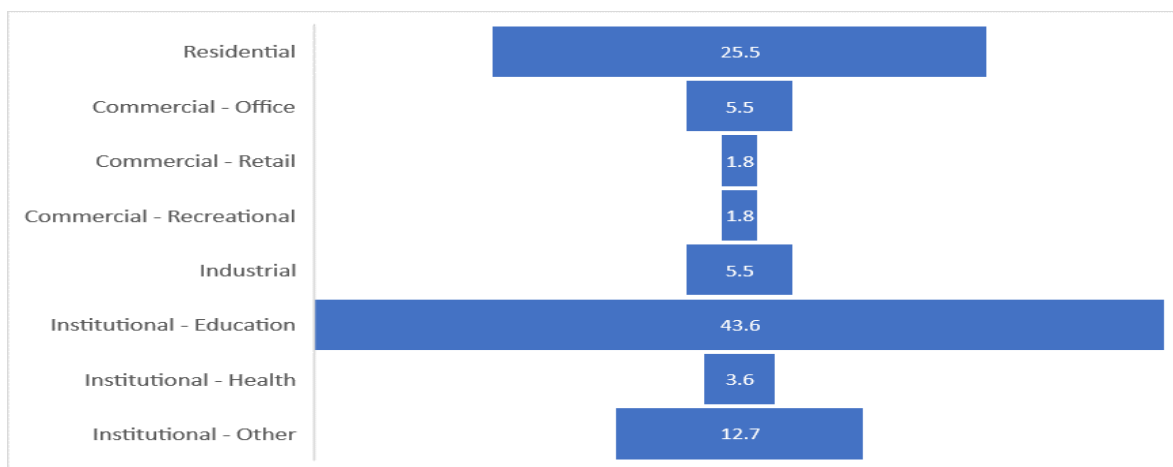


Figure 4 Type of Facility Being Built

Source: Researcher' construct (2024)

Figure 4 presents the type of facilities that respondents have managed. Most of the respondents (43.6%) have managed educational instruction projects that may have up to six floors. Following that, 25.5% of the respondents have managed residential buildings that may have more than two (2) floors. Additionally, 12.7% have managed other institutional facilities, such as offices. These findings highlight the importance of comprehensive project management to mitigate potential accident risks.

Table 5 Number of Floors of Project Handling

	Number of floors	Frequency	Percent	p-value
	1	18	34.0	< 0.001
	2	9	17.0	
	3	24	45.3	
	4	2	3.8	
	Total	65	100.0	

Source: Researcher' construct (2024)

Table 5 indicates the number of floors of projects respondents have handled.

The average number of floors of projects that respondents have handled is three representing 45.5%. This reveals that the sample selection of the respondents is good, indicating they may have adequate knowledge on accidents on construction sites.

4.3 Analysis of Questionnaire Section B Based on Respondents' Responses

This section presented and discussed the research data analyses and findings based on the questionnaire survey's responses of various ranked factors and statements in accordance with the research questions and objectives.

4.3.1 Key Factors Causing Falling Object Accidents on Construction Sites

Table 6 presents the respondents ranking of the causes of falling object accidents on construction sites.

Table 6 Causes of falling object accidents on construction sites

Code No.	Key Factors Causing falling object accidents	Mean scores	Std. Deviation	Chi Square test p-values	Rank
15.1	Debris and materials falling from planks or loads while being lifted	2.61	1.384	0.000	1
15.2	Materials left at edges unsecured	2.52	1.662	0.335	2
15.3	Missing toe on scaffolding/kick boards	2.50	1.561	0.028	3
15.4	Holes in safety netting/gaps between perimeter safety screen	2.43	1.500	0.017	4
15.5	Being blown from structures by wind	2.30	1.476	0.001	5

Source: Researcher's Construct (2024)

Table 6, presents the respondents ranking of the causes of falling object accidents on construction sites. The first three factors ranked in the table all have a slight influence on the causes of this accident on the construction site. The factor with the most significant influence is debris and materials falling from planks or loads while being lifted, with an MS=2.61. This is often a direct impact of negligence which could have been avoided by proper monitoring and having an orderly, organised environment on site, unsecured building materials left at the edge, with an MS = 2.52 was rated next to debris and materials falling from planks or loads while being lifted. Accidents result from materials not being properly placed on board while working; materials are blown away from the structure by the wind with an MS=2.30, which is ranked the least because of the fact that the KwaZulu-Natal province is not a region associated with high wind pressure.

4.3.2 Key Factors Causing Falling from Height Accidents on Construction Sites

Table 7 reveals the various factors contributing to falls from height accidents on construction sites

Table 7 Causes of falling from heights accident on construction sites

Code No.	Key Factors Causing falling from height accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
16.1	Insufficient or lack of Training	2.89	1.670	0.009	4
16.2	Weak planking	3.11	1.557	0.039	2
16.3	Insecure bracing	3.41	1.807	0.000	1
16.4	Overloading	3.07	1.787	0.082	3
16.5	Ignoring safety rules (protocol)	2.66	1.443	0.000	5

Source: Researcher's Construct (2024)

Table 7 reveals the various factors that cause falls from height accidents on construction sites. In this construct, the first three factors have a moderately significant influence on factors causing falls from height, while the other two factors have slight significant influence in fall from height accidents. Insecure bracing with a mean score of 3.41 is ranked as the most frequent factor that results in a fall from height accident. To ensure safety and stability on scaffolding platforms every scaffold must be properly secured or braced. Working on scaffolding without proper bracing is extremely dangerous and poses serious risks. The next factor rated is weak planking with an MS of 3.11; this would easily bring down the scaffolding when the load weighs more than the scaffold. The lack of or insufficient training is ranked least, assembling a scaffolding platform requires some technicality, and, as such, it is uncommon to find a skilled labourer who is not trained to erect a scaffold.

4.3.3 Key Factors Causing Electrocution Accidents on Construction Sites

Table 8 indicates the respondents rating of the causes of electrocution accidents on construction sites.

Table 8 Causes of electrocution accidents on construction sites

Code No.	Key Factors Causing Electrocution Accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
17.1	Improper use of extension and flexible cords.	2.89	1.614	0.020	1
17.2	Contact with energized sources	2.45	1.628	0.313	2
17.3	Contact with overhead power lines	2.36	1.645	0.141	3

Source: Researcher's Construct (2024)

Table 8 indicates the respondents rated the causes of electrocution accidents on construction sites. Thus, improper use of extension and flexible cords with an MS of 2.89 was rated the most influential factor causing electrocution accidents. The mean score suggests a slightly significant influence. The rating indicates that contact with the overhead power line is the least likely factor to cause electrocution accidents. This is due to the fact that the overhead power line is at a higher level than the place/area of work, therefore, the contact with overhead power line is zero.

4.3.4 Key Factors Contributing to Structure Collapse on Construction Sites

Table 9 reveals the respondents rating of the causes of structure collapse accidents on construction sites.

Table 9 Causes of structure collapse on construction sites

Code No.	Key Factors contributing to structure collapse	Mean score	Std. Deviation	Chi Square test p-values	Rank
18.1	Poor skilled labour	3.00	1.651	0.088	1
18.2	Excessive loading	2.98	1.635	0.382	2
18.3	Substandard materials	2.89	1.557	0.164	3
18.4	Brief and designs deficiencies	2.84	1.735	0.131	4
18.5	Natural occurrence	2.43	1.582	0.382	5

Source: Researcher's Construct (2024)

Table 9 presents the respondents rating of the factors that cause structure collapse accidents on construction sites. The factor poorly skilled labour was rated as the primary factor contributing the most to the occurrence of structure collapse on-site. The possible reasons for structure collapse include the incorrect application of construction methods and the use of inappropriate materials, both of which can lead to structural failures. The second factor that influences structure accidents is excessive loading. Excessive loading creates an uneven balance, resulting in pressure on one side, which is then balanced by forces on the other side, ultimately leading to the accident. Natural occurrence was rated as the least contributing factor causing structure accident. This is because KwaZulu-Natal, as a region, rarely experiences extreme wind pressure, which could lead to the collapse of a structure.

4.3.5 Key Factors Contributing to Crane Accidents on Construction Sites

Table 10 presents respondents' ranking of various factors contributing as a main causes of crane accidents on construction sites.

Table 10 Causes of crane accidents on construction sites

Code No.	Key Factors contributing to crane accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
19.1	Operators carelessness	2.93	1.639	0.033	1
19.2	Noncompliance with safety measures stated while working with and on the crane	2.93	1.746	0.121	2
19.3	Tight working environment	2.84	1.535	0.164	3
19.4	Working in a Hazardous weather condition	2.82	1.696	0.358	4
19.5	Poor communication	2.75	1.632	0.744	5
19.6	Poor work supervision	2.73	1.612	0.273	6
19.7	Ignorance and working with a faulty crane	2.73	1.824	0.581	7
19.8	Use of component that does not fulfill the required technical specifications	2.70	1.715	0.237	8
19.9	Overloading	2.66	1.719	0.103	9
19.10	Obstruction of vision	2.64	1.519	0.014	10
19.11	Unqualified operator operating the crane	2.64	1.783	0.001	11
19.12	Failure of track and buffer of the crane	2.63	1.701	0.255	12
19.13	Unsanitary and unorganised working environment.	2.61	1.569	0.028	13
19.14	Motorised and adjustable lifting system failure	2.59	1.570	0.164	14
19.15	Failure of loading Ropes	2.57	1.605	0.075	15

Source: Researcher's Construct (2024)

Table 10 reviews the respondents' ranking of various factors that result in accidents involving cranes on construction sites. The respondent's identified the operator's carelessness as the most significant factor contributing to crane accidents. This is followed by non-compliance with safety measures while working with cranes, ranked as the second most critical factor. A tight working environment was ranked third, while the last on the list of ranking was the failure of loading ropes, which was considered the least significant factor among those on the list

4.3.6 Key Nature of Vibrating Tool Causing Hazard on Construction Sites

Table 11 presents the cause of vibrating tool hazards on construction sites in KwaZulu-Natal's construction industry.

Table 11 Nature of vibrating tool causing hazard on construction sites

Code No.	Key nature of vibrating tool causing hazard on construction sites	Mean score	Std. Deviation	Chi Square test p-values	Rank
20.1	Grinders	2.84	1.487	0.152	1
20.2	Clipping hammers	2.82	1.363	0.000	2
20.3	Rammers & drills	2.80	1.407	0.003	3
20.4	Chain saw	2.54	1.477	0.003	4
20.5	Site vehicles	2.61	1.603	0.020	5

Source: Researcher's Construct (2024)

Table 11 presents the cause of vibrating tool hazards on construction sites in KwaZulu-Natal's construction industry. The frequent use of grinders, with an MS = 2.84 was rated as the factor that has the highest influence in causing vibrations that lead to accidents. The second factor with the most influence in causing vibrating tool accidents is the consistent use of clipping hammers with an MS = 2.82. This could lead to a head strain causing a lack of concentration and resulting in an accident.

4.3.7 Major Effects of Falling Objects Accident on Construction Sites

Table 12 indicates respondents rating of the effect of falling object accidents on construction site.

Table 12 Effects of falling objects accident on construction sites

Code No.	Major effects of falling objects accident on construction sites	Mean score	Std. Deviation	Chi Square test p-values	Rank
21.1	Fracture	3.07	1.693	0.021	1
21.2	Fatalities	2.98	1.657	0.008	2
21.3	Legal expenses	2.84	1.671	0.000	3
21.4	Strain	2.80	1.566	0.069	4
21.6	Burns and cut	2.38	1.556	0.131	6
21.7	Back injuries	2.73	1.578	0.221	7

Source: Researcher's Construct (2024)

Table 12 indicates respondents' ratings of the effect of falling object accidents on construction sites with respect to the frequency of occurrences; the factor fracture with MS = 3.07 was rated as the most occurring effect of every accident that involves an object falling from height to injure workers and passersby at lower height levels. The human body is very fragile, and any impact on the body may cause damage. A common effect of falling object accidents is fractures, and the second type of effect of this accident is fatalities. The least frequent factor of the effect of falling objects is back injuries. Arguably this factor should be one of the more common effects, but being rated as having the least effect is probably due to objects mostly falling on individuals from the front.

4.3.8 Major effects of electrocution accident on construction sites

Table 13 indicates respondents rating of the effect of electrocution accidents on construction site.

Table 13 Effects of electrocution accidents on construction sites

Code No.	Major effects of electrocution accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
22.1	Cost of case litigation process	3.05	1.381	0.000	1
22.2	Damage of plants and equipment	3.05	1.554	0.002	2
22.3	Damaged reputation to the employer	3.18	1.323	0.000	3
22.4	Payment of settlement for injuries & death	3.11	1.448	0.000	4
22.5	Disruption of site operation	2.96	1.401	0.000	5

Source: Researcher's Construct (2024)

Table 13 indicates respondents' ratings of the effect of electrocution accidents on construction sites. The cost of the case litigation process per unit measured at MS = 3.05, is noted as the most significant consequence of electrocution accidents on sites. The reason for this may be that this type of accidents involves human beings and may cause destruction or damage to parts of the body that renders the worker unable to work. They may procure compensation that such a worker may demand. The secured rated effect, or electrocution accident, is damage to plants and equipment unit an MS = 3.05. It is obvious there that there may be damage to plants and equipment due to the accident; the plant and equipment are no longer working. The electrocution accident has the least effect on the site operation unit with an MS = 2.96. The mean score indicates that this factor has a slight to moderate influence on project delay that is somewhat significant.

4.3.9 Major effects of collapse of structure accident on construction sites

Table 14 reveals the rating of various effects of collapse of structure accident on construction sites.

Table 14 Effects of collapse of structure accidents on construction sites

Code No.	Major effects of collapse of structure accident	Mean score	Std. Deviation	Chi Square test p-values	Rank
23.1	Injuries	3.57	1.536	0.000	1
23.2	Loss of time	3.55	1.513	0.000	2
23.3	Death	3.39	1.670	0.000	3
23.4	Loss of profit	3.21	1.615	0.025	4
23.5	Permanent and non-permanent disability	3.20	1.656	0.004	5

Source: Researcher's Construct (2024)

Table 14 illustrates the ratings of various effects resulting from structure collapse accidents on construction sites. The faster injuries (MS = 3.55) was rated as the most frequent effect of collapse accidents, primarily due to the lack of worker preparedness before the accident and the risk of objects falling on them. If results at any time reveal a rating of loss of time (MS = 3.55), it is because more time would be needed to complete the construction in the event of structure collapse either partial or complete. This includes the need to clean up the debris from the collapse, order more materials, and allow time for the reconstruction, all of which contribute to project delays. This leads to a loss of time on the project. Deaths are rated as the third most frequent effect of such accidents. The factor workers involved in the collapse incurring disability both permanently and temporarily (MS = 3.20) was rated as the least frequent effect. This table is characterised by factors that have a moderate significance in the context of construction site accidents, as all mean scores are greater than three.

4.3.9 Major Effects of Crane Accident on Construction Sites

Table 15 presents the ranking of the different effects of crane accidents on construction sites.

Table 15 Effects of crane accidents on construction sites

Code No.	Major effects of crane accident on construction sites	Mean score	Std. Deviation	Chi Square test p-values	Rank
24.1	Death	3.52	1.640	0.000	1
24.2	Shock	3.30	1.374	0.001	2
24.3	Fracture	3.30	1.560	0.000	3
24.4	Nerve damages	3.23	1.489	0.000	4
24.5	Cardiac arrest	3.23	1.489	0.001	5
26.6	Muscular contraction	2.89	1.461	0.000	6
24.7	Been blow away from contact e.g., circuit	2.61	1.534	0.054	7
24.8	Serve burns	2.52	1.489	0.007	8

Source: Researcher's Construct (2024)

Table 15 presents the ranking of the different effects of crane accidents on construction sites; death is ranked as the most frequent consequence of this type of accident on construction sites with a mean score of 3.52, followed by shock. Fracture ranks third, slightly lower than shock, while severe burns rank last.

4.3.10 Major Effects of Vibrating Tool Hazards on Construction Sites

Table 16 presents the ranking of the different effects of vibrating tool hazards on construction sites.

Table 16 Effects of vibrating tool hazards on construction sites

Code No.	4.3.10 Major effects of vibrating tool hazards on construction sites	Mean score	Std. Deviation	Chi Square test p-values	Rank
25.1	Neurological disorder	3.43	1.438	0.000	1
25.2	Disorder of the sensory function/ reduction in tactile sensitivity	3.25	1.455	0.001	2
25.3	Loss of manual dexterity	3.23	1.465	0.001	3
25.4	Neck and Shoulder Pain	3.18	1.309	0.000	4
25.5	Cardiovascular disease	3.00	1.401	0.000	5
25.6	Joint Damage	2.88	1.294	0.000	6

Source: Researcher's Construct (2024)

4.3.11 Key Preventive Measures Against Falling Object Accidents on Construction Sites

Table 17 reveals various preventive measure that could be implemented on site to prevent the occurrence of falling object accidents.

Table 17 Preventive measures against falling object accidents on construction sites

Code No.	Key Preventive measures against falling object accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
26.1	Good maintenance and ensuring good condition of equipment and tools	3.84	1.424	0.000	1
26.2	Employment of Qualified workers	3.84	1.437	0.000	2
26.3	Effective Health and Safety Training	3.84	1.462	0.000	3
26.4	The use of PPE when on construction site	3.77	1.452	0.000	4

26.5	Effective communication to overcome issues of language barrier	3.29	1.371	0.000	5
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Source: Researcher's Construct (2024)

Table 17 reveals various preventive measure that could be implemented on site to prevent the occurrence of falling object accidents, and ranks the factors in order of effectiveness. Maintaining a good site environment and maintaining tools and equipment in good conditions ranks as the most significant measure that could be adopted. Employing qualified personnel is ranked second. while tackling the issue of the language barrier ranks as the least significant factor to be considered in preventing the occurrence of this accident

4.3.12 Key Preventive Measures Against Fall from Height Accidents on Construction Sites

Table 18 Preventive measures against fall from height accidents on construction sites

Code No.	Key Preventive measures against fall from height accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
27.1	Effective Health and Safety Training	3.89	1.330	0.000	1
27.2	Effective use of PPE during site operations	3.80	1.407	0.000	2
27.3	Good maintenance and ensuring good condition of equipment and tools	3.73	1.471	0.000	3
27.4	Employment of Qualified workers	3.66	1.431	0.000	4
27.5	Effective communication to overcome issues of language barrier	3.41	1.523	0.002	5

Source: Researcher's Construct (2024)

Table 18 presents measures for the prevention of falls from height and scaffolding accidents. The factor with the highest rating is training of workers with an MS = 3.89. Building construction activities are risky and can easily lead to slips and falls. Every

activity requires adequate experience and knowledge. Only a well-detailed and organised training can address the lack of this required knowledge and expertise. The second-rated factor having a moderately high influence in preventing accidents from height and scaffolds is the use of personal protective gear with an MS = 3.80. The third-rated factor that could prevent height and scaffolding accidents is the good maintenance of construction tools used on site with an MS = 3.73. Strict enforcement of regulations and compliance by workers will significantly assist in minimizing accidents on construction sites.

4.3.13 Key Preventive Measures Against Structure Collapse Accidents on Construction Sites

Table 19 presents measures for the prevention of structure collapse accident.

Table 19 Preventive measures against structure collapse accidents

Code No.	Key Preventive measures against structure collapse accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
28.1	Strict and consistent supervision by professionals	3.89	1.330	0.000	1
28.2	Involvement of proper professionals at every stage of construction	3.80	1.407	0.000	2
28.3	Regulations of building load	3.73	1.471	0.000	3
28.4	Building approval before permission to construct building	3.66	1.431	0.000	4
28.5	Live load and dead load proper calculation by structural engineers to prevent overloading	3.41	1.523	0.002	5
28.6	Investigation of soil bearing capacity before design of structure.	3.32	1.515	0.000	6

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Source: Researcher's Construct (2024)

Table 19 presents measures for the prevention of structure collapse accidents. The factor with the highest rating is strict and consistent supervision by professionals with an MS = 3.89. Building construction activities are inherently risky and prone to slips and falls. Every activity requires adequate supervision. The lack of supervision at all stages and levels is the reason for accidents on site. The second-rated factor having a moderately high influence in preventing accidents from height and scaffolding is the involvement of proper professionals at every stage of construction with an MS = 3.10. Professionals are certified as competent and qualified to handle work by their common professional councils. Therefore, the work they engage in is expected to be safe and completed accurately if all things go on well. The third-rated factor that could prevent height and scaffolding accidents is the building code regulations with an MS = 3.73. The enforcement and compliance by workers to regulation will greatly assist in minimizing accidents on construction sites.

4.3.12 Key Preventive measures against electrocution accidents on construction sites

Table 20 presents the key preventive measures against electrocution accidents on KwaZulu-Natal construction sites.

Table 20 Preventive measure against electrocution accidents on construction sites

Code No.	Key Preventive measures against electrocution accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
29.1	Use power tools and equipment as instructed by designer	3.91	1.418	0.000	1
29.2	Inspects extension cords and portable tools for opening that	3.82	1.390	0.000	2

	could lead to transmission of electric current before use.				
29.3	Use ground fault circuit interrupter (GFCI)	3.80	1.445	0.000	3
29.4	Use overhead power line distance warning device for heavy equipment and vehicles such as trucks, crane and so on.	3.80	1.482	0.000	4
29.5	Follow tag out procedures or lockout Procedure	3.73	1.446	0.000	5
29.6	Maintaining a safe distance from overhead powerline.	3.70	1.536	0.000	6
29.7	Avoid working in the rain until it is safe to return is work in areas where there is close proximity to electricity.	3.16	1.233	0.000	7

Source: Researcher's Construct (2024)

Table 20 reveals the preventive measures against electrocution accidents on KwaZulu-Natal construction sites. As all of the factors in this construct have mean scores greater than 3, they all have a moderately significant influence in preventing electrocution accidents. The use of power tools and equipment as instructed by designers with an MS = 3.11 was rated as the most significant factor measuring preventing electrocution accidents. Inspecting of extension and portable cords for opening before use with an MS = 3.82 was rated second. When the safety rule is performed, it reveals possible points of danger and can be fixed before usage for safety. Avoiding work in close proximity to electricity during rain, with an MS = 3.16 rate, is the least factor in the prevention of electrocution accidents. It is very uncommon to work on construction sites while it is raining, as it is logical and common sense not to work in such conditions. This may be the reason why this factor was rated least significant.

4.3.14 Key Preventive Measures Against Crane Collapse Accidents on Construction Sites

Table 21 presents the respondents ranking of measures that could be considered to prevent the occurrence of crane accidents on construction sites.

Table 21 Preventive measures against crane accidents on construction sites

Code No.	Key Preventive measures against crane collapse accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
30.1	Effective Site's Safety management	3.84	1.558	0.000	1
30.2	Environmental factor such as proper housekeeping and good condition and organised working environment	3.73	1.543	0.000	2
30.3	Making use of sign boards & communication boards	3.73	1.567	0.000	3
30.4	Constant supervision	3.73	1.578	0.000	4
30.5	Employing a licensed and qualified operator	3.77	1.640	0.000	5
30.6	Avoidance of communication barrier	3.64	1.507	0.000	6
30.7	Effective monitoring and avoidance of overloading	3.50	1.673	0.000	7

Source: Researcher's Construct (2024)

Table 21 presents respondents' ranking of measures that could be considered to prevent the occurrence of crane accidents on construction sites; safety management ranks as the most important factor, environmental factors such as workers working in good environments rank as second, avoiding overloading the crane ranks as the least important factor to be considered in preventing this accident on construction sites.

4.3.15 Key Preventive Measures Against Vibrating Tool Hazards Accidents on Construction Sites

Table 22 presents individual respondents' ratings of preventive measure in reducing vibrating tool accidents on construction sites during operation.

Table 22 Preventive measures against vibrating tool hazards on construction sites

Code No.	Key Preventive measures against vibrating tool hazards accidents	Mean score	Std. Deviation	Chi Square test p-values	Rank
31.1	Effective Health and Safety Training	3.77	1.501	0.000	1
31.2	Maintaining tools properly and regularly	3.63	1.624	0.000	2
31.3	Proper grip and right handling technique to reduce vibration	3.57	1.488	0.000	3
31.4	Use of gloves and protective clothing	3.48	1.549	0.000	4
31.5	Seats should have proper vibration absorption material in case of whole-body vibration from vehicles.	3.46	1.489	0.001	5
31.6	Selecting or buying a low vibrating tool	3.34	1.311	0.000	6
31.7	Regular driving surface	3.25	1.540	0.000	7

Source: Researcher's Construct (2024)

Table 22 presents the individual respondents ratings based on preventive measures in reducing vibrating tool accidents that could occur as a result of using vibrating tools on construction sites. Training of workers with MS = 3.63 was rated as the most significant measure that could mitigate vibrating tool accidents. Proper maintenance of these tools that vibrate with MS = 3.63 was rated as the second factor. Training capacitates individuals with the necessary knowledge to operate machines, tools and equipment. The training will provide the individual with comprehensive knowledge on how to operate the

machine, tool, and equipment safely and effectively. The second factor was the proper maintenance of these vibrating tools. Having a regular driving surface with an MS = 3.25 was rated as the least effective preventive measure. This rating is so because tools and equipment after the main factors is without defect. The tools and equipment are tested reactively to the enquiry test required or they are certified satisfactory. The grinding surface of equipment would have passed the regulation test before being put onto the mantel for sales and use.

4.4 Commonality Testing of The Key Issues of Construction Site Accidents.

This section of the research study presents the commonality test based on commonality coefficient value with regards to the data analyses emanating from the research respondents on key issues on the causes of site accidents, their implications and potential preventive measures in the KwaZulu-Natal construction sector. Thus, Tables 23, 24, and 24 highlight the commonality test of this study.

Table 23 Test for Commonality factors/variable as common causes of construction site accidents in KwaZulu-Natal

S/No	Code No. (Factors for commonality)	Mean Score	Rank	Chi-Square P-Value	Commonality Coefficient Value
1	19.9	2.84	1	0.164	0.948
2	16.4	3.07	2	0.082	0.943
3	16.5	2.66	3	0.000	0.941
4	19.14	2.62	4	0.014	0.938
5	19.15	2.82	5	0.358	0.934
6	15.5	2.3	6	0.001	0.933

7	19.3	2.73	7	0.273	0.926
8	19.11	2.63	8	0.255	0.926
9	19.5	2.82	9	0.358	0.925
10	19.4	2.64	10	0.014	0.924
11	19.1	2.75	11	0.744	0.921
12	16.3	3.41	12	0.000	0.919
13	16.1	2.89	13	0.009	0.918
14	19.10	2.64	14	0.001	0.915
15	18.2	2.98	15	0.382	0.908

Source: Researcher's Construct (2024)

Table 23 presents the commonality test that was performed in order to group general or common causes of construction site accidents. The test identifies the underlying causes of all types of accidents on construction sites. Knowledge of these general causes means that giving attention to them will impact on all activities and reduce accidents on sites.

Table 24 Test for Commonality factors/variables in the identification of the general effect of construction site accidents

S/n	Code (Factors for commonality)	No. for	Mean Score	Rank	Chi- Square P-Value	Commonality Coefficient Value
1	21.3		2.84	1	0.000	0.950
2	21.6		2.38	2	0.131	0.943
3	21.7		2.73	3	0.221	0.942
4	23.2		3.05	5	0.002	0.926
5	25.6		2.89	6	0.000	0.922
6	24.2		3.55	7	0.000	0.915

7	24.4		3.21	8	0.025	0.910
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Source: Researcher's Construct (2024)

Table 24 presents, in the same way, the general effect of accidents on construction sites that would assist in developing the mitigation strategy that may be applied on site to all, if not, all types of accidents.

Table 25 Test for Commonality factors/variables in the identification of common preventive remedies of construction site accidents

S/N	Code No. (Factors for commonality)	Mean Score	Commonality Coefficient Value	Chi-Square P-Value	Rank
1	31.6	3.64	1	0.000	0.966
2	31.2	3.73	2	0.000	0.963
3	31.4	3.73	3	0.000	0.960
4	30.6	3.70	4	0.00d0	0.955
5	27.2	3.84	5	0.000	0.953
6	29.4	3.80	6	0.000	0.95
7	31.3	3.73	7	0.000	0.949
8	27.3	3.84	8	0.000	0.944
9	30.3	3.73	9	0.000	0.944
10	30.1	3.89	10	0.000	0.942
11	31.5	3.77	11	0.000	0.933
12	27.1	3.84	12	0.000	0.922
15	31.1	3.84	15	0.000	0.913

Source: Researcher's Construct (2024)

Table 25 presents a unified view of identifying of common key factors and remedial measures on site that will help focus attention, cost and energy in particular directions to yield great results. Consequently, this will afford the reduction of accidents on site generally.

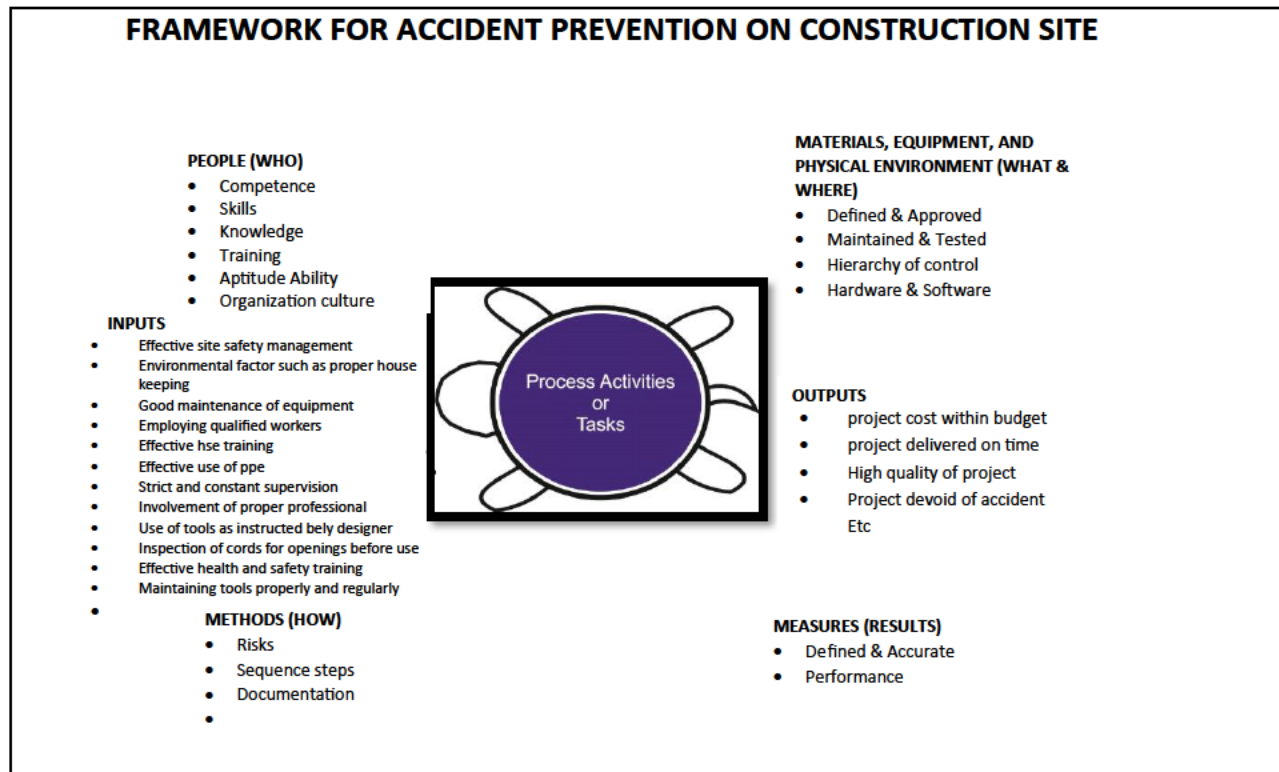


Figure 5 Author's Improved ISO 4001 occupational health and safety management system

Source: Researcher's Construct (2024)

Figure 5, presents a framework for the prevention of accidents on construction site. The framework is developed based on input and output, where the input is ensured by a worker who is competent and highly skilled, well trained and knowledgeable with an aptitude ability and an organized culture to ensure effective site safety management, ensure good environmental factor such as proper housekeeping, good maintenance of tools, make sure only qualified workers are employed on site, ensure effective HSE training, enforce an effective use of PPE, maintain a strict and constant supervision on site, involve the proper professional at every stage of construction, ensure tools are used as instructed by designers, inspect cords for opening before use, through a sequenced steps and good documentation which would result in an output which includes mitigated risk on construction site, improved workers HSE, safe site, on time delivery of project and well maintained reputation for the management

4.5 Chapter Conclusive Remark

This chapter presented and analyzed the data collected in tables and figures, which yielded findings in accordance with the research questions. The findings were discussed within the context of the set research objectives. Based on the findings regarding the mitigation of accidents on construction site, the table below represents a frame work for the prevention of accidents.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This research study was based on a five-chapter framework. Chapter One addressed the overarching issues related to the discourse around the major causes of health and safety accidents on construction site. It also provided the foundational background highlighting the research problem, research questions, aim and objectives, and ethical considerations observed during the study. Chapter Two of this study extensively discussed various concepts, theories, ideas, perspectives, and frameworks on some of the nature, causes and effects of construction site accidents and their implications. Chapter Three discussed and justified the research method, techniques, design, and philosophical approaches adopted, as well as the research data collection and sampling methods used. Chapter Four extensively presented, analyzed and discussed the key results and findings of the study. Chapter Five of this research study presented a brief recap of the research questions, research aim and objectives and the summary of the key findings emanating from the study, which indicated how the research objectives were achieved and the research questions obtained accordingly. Chapter Five further presents the general conclusion based on the key research results as well as the presentation of the general recommendations and the areas for further research endeavors.

5.2 Recap of Research Questions, Aim and Objectives

Research Question: The following is a recap of the research questions, aim and objectives, which guided this study in addressing the identified problem in relation to major causes of health and safety on construction sites and its effect and potential prevention strategies.

- What are the various causes of the construction site accidents in the KwaZulu-Natal construction industry.?
- What are the critical effects of construction site accidents on workers and projects in the KwaZulu-Natal construction industry.?

- What are the various preventive and action-orientated strategies for the effective mitigation of construction site accidents in the KwaZulu-Natal construction industry.?

Aim of the Study: The following statement is the aim of the study:

The aim of this study is to assess effective management strategies for the prevention of accidents, occupational injuries and related risks on construction sites in KwaZulu-Natal's construction industry.

Objectives of the Study: The following statements are the objectives of the study:

- To identify and assess the causes of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry.
- To assess the resultant effect of construction site accidents and occupational injuries among workers in KwaZulu-Natal's construction industry.
- To assess and recommend strategies that would assist in mitigating construction site accidents and occupational injuries in KwaZulu-Natal's construction industry.

5.3 Key Summary Based on Research Objectives

Thus, the following are key summaries of the findings in accordance with the study objectives.

5.3.1 Research Objective One

This objective set out to identify and assess the causes of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry. Accordingly, major causes of construction site accidents include factors such as falling objects and accidents from heights. These can be attributed to factors such as debris and materials falling from planks or loads while being lifted; materials left unsecured at edges; missing toe boards/kick boards on scaffolding; insufficient or lack of training; weak planking and insecure bracing; overloading; and ignoring safety protocols respectively. While the electrocution accidents on construction sites are majorly as a result of improper use of extension and flexible cords, contact with energized sources, and contact with overhead

power lines by addressing these issues, construction sites can significantly reduce the risk of accidents. Regular safety audits, proper training, and adherence to safety protocols are essential in creating a safer work environment.

In addition, the major factors contributing to structural collapse accidents on construction sites are poor skilled labour, excessive loading, usage of substandard materials, deficiencies on building briefs and design packages, and, to some extent, natural occurrences. The study's findings indicated that the major causes of crane and vibration tool accidents on construction sites are the resultant effects of operators' carelessness, workers' noncompliance with safety measures while working with and on the cranes, tight working environments, working in hazardous weather conditions, poor communication issues, poor work supervision, ignorance, working with faulty cranes, using components that do not meet the required technical specifications, and overloading.

All these factors contributed significantly to construction site accidents in the KwaZulu-Natal construction sector. Thus, the Cronbach's alpha value test-based analysis on key factors contributing to construction site accidents shows the causes of falling object accidents (0.893), causes of fall from height accidents (0.943), causes of electrocution accidents (0.923), causes of structure collapse accidents (0.904), causes of crane accidents (0.980) and causes of vibrating tool hazards (0.922) are all significant. Thus, this is an indication of the high reliability of data, as all the key factors measured and analysed had a Cronbach's alpha value that was greater than 0.60. Therefore, this research question was answered, and the study's objectives were achieved based on the testing and findings of Cronbach's alpha, which shows the reliability of the data collected and analysed and how well it corroborated with other studies empirical findings.

5.3.2 Research Objective Two

This objective set out to assess the resultant effect of construction site accidents and occupational injuries among workers in the KwaZulu-Natal construction industry. Accordingly, key effects for construction workers and firms based on construction site accidents emanating from falling objects and from height accidents are fractures, fatalities, legal expenses, strain, burns and cut, and back injuries, as well as major effects

of electrocution accidents, which are the cost of the case litigation process, damage of plants and equipment, damage to the reputation of the employer, payment of settlement for injuries and death, and disruption of site operation. On the other hand, major effects of collapse of structure accidents reflect, in some cases, death, shock/trauma, fractures and nerve damage, cardiac arrest, muscular contractions, blowing away from point of contact (for example, a circuit) and severe burns. The improper usage of vibrating tools can cause hazards on construction sites, with resultant effects, such as neurological disorder, disorder of the sensory function (such as a reduction in tactile sensitivity), loss of manual dexterity, somewhat permanent neck and shoulder pain, cardiovascular disease, and joint damage.

However, using the Cronbach's alpha value test-based analysis on key factors contributing to construction site accidents indicated that major resultant effects of falling object construction site accidents have Cronbach's alpha value of 0.957; effects based on falling from height site accidents (0.945), effects of electrocution construction site accidents (0.944), effects on the structure collapse of construction site accident (0.907), effects based on of crane construction site accidents were 0.944; and effects emanating from improper use of vibrating tools causing hazards on accident on sites was 0.943.

Therefore, all these reported effects were considered as the major resultant effects significantly affecting workers and organisations based on issues of construction site accidents in the KwaZulu-Natal construction sector. Thus, this is an indication of the high reliability of data, as all the key factors measured and analyzed based on resultant effects construction site accidents on construction workers and firms have a Cronbach's alpha value that is greater than 0.60. Therefore, this research question was answered, and the study objective was achieved based on the testing and calculated Cronbach's alpha value which ascertained the reliability of data collected and analyzed, corroborating with empirical findings from other studies.

5.3.3 Research Objective Three

This objective set out to assess and recommend strategies that would assist in mitigating construction site accidents and occupational injuries in KwaZulu-Natal's construction

industry. Accordingly, some of the strategies recommended as key preventive measures against falling objects and fall from height accidents on construction sites are good maintenance and ensuring good condition of equipment and tools, employing qualified workers, effective health and safety training, using PPE on construction sites, effective communication to overcome language barriers, and effective usage of health and safety training. These measures were considered key preventive strategies towards mitigating the high incidences of construction site accidents. On the other hand, strategic measures such as strict and consistent supervision by professionals during site operation, involving relevant professionals at every stage of the construction, adhering to building load regulations, seeking building approval/permission before a building construction, ensuring that live load and dead load are properly calculated by professional structural engineers to prevent overloading, and investigating the soil bearing capacity before design of structure and construction starts are considered as some of the key preventive measures towards reducing or mitigating issues of construction structure collapse accidents on sites.

While, measures such as the use of power tools and equipment as instructed by designer, the inspection of extension cords and portable tools for opening that could lead to transmission of electric current before use, avoiding the use of ground fault circuit interrupters (GFCI), the use overhead power line distance warning devices for heavy equipment and vehicles such as trucks, crane and so on, following tag out or lockout procedures, maintaining a safe distance from overhead powerlines, and avoiding work in the rain until it is safe to return to work in areas of close proximity to electricity were considered key prevention measures that would significantly contribute in mitigating construction site accidents as a result of electrocution accidents. In addition, the study summarises the following as key preventive measures against crane collapse site accidents, such as effective site safety management, environmental factors such as proper housekeeping and good condition and organised working environments, making use of sign boards and communication boards, constant and effective supervision, employing a licensed and qualified operator, avoidance of communication barriers, and effective monitoring and avoidance of overloading.

Furthermore, effective usage of health and safety training, proper and regular maintenance of construction tools, proper grip and right handling technique to reduce vibration, and the use of gloves and protective clothing are highly recommended as some key preventive measures and strategies to mitigate against vibrating tool-causing construction site hazards and accidents in the KwaZulu-Natal construction sector. However, a Cronbach's alpha value test-based analysis was conducted on key preventive measures or strategies to mitigate major issues causing construction site accidents. The study summaries indicated that the identified factors, strategies, and measures would significantly contribute as preventive strategies to minimise or eradicate construction site accidents. Thus, preventive measures against falling object accidents have a Cronbach's alpha value of 0.925, and measures against falls from height accidents were 0.949. measures against electrocution accidents recorded 0.941, while measures against collapse of structure accidents were 0.953, measures against crane accidents were 0.964, and preventive measures against vibrating tool hazards were 0.937. Therefore, this is an indication of high data reliability, as all the key factors measured and analysed based on resultant effects construction site accidents on construction workers and firms have a Cronbach's alpha value that is greater than 0.60. Therefore, this research question was answered, and the study objective was achieved based on the testing and calculated Cronbach's alpha value generated in ascertaining the reliability of data collected and analysed and corroborates other studies' empirical findings.

5.4 General Research Conclusions

The main purpose for undertaking this empirical research study was to identify and assess effects of site accidents and to uncover some of effective measures and strategies for the prevention of accidents, occupational injuries, and related risks on construction sites in the KwaZulu-Natal construction industry. This was achieved by investigating and uncovering the major causes of construction site accidents, and their main negative implications, as well as potential preventive measures and strategies to reduce and mitigate the main sources of construction site accidents within the KwaZulu-Natal construction sector. Thus, this study's conclusions are based on statistical analysis and

discussion of data collected from research respondents, which enables the researcher to draw empirical conclusions on key causes and main effects of construction site accidents as well as potential preventive measures and strategies to effectively manage and mitigate key sources of accidents, occupational injuries and related risks on construction sites in the KwaZulu-Natal construction industry during project delivery on sites. Thus, in accordance with the analysis and discussion of data collected, and findings emanating from it, the study concluded that the significant factors contributing to major construction site accidents within the KwaZulu-Natal construction sector are issues or factors such as debris and materials falling from planks or loads while being lifted, missing toe on scaffolding/kick boards; insufficient or lack of training, overloading, ignoring safety rules (protocol), improper use of extension and flexible cords, contact with energised sources and overhead power lines, poor skilled labour, excessive loading, usage of substandard materials, deficiencies on building Brief and design packages, and somewhat natural occurrence, operators' carelessness by workers, noncompliance with safety measures stated while working with and on the crane, tight working environment, working in a hazardous weather condition, issues of poor communication, and poor work supervision during construction project delivery on sites.

However, based on findings, the research revealed and concluded that some of the major effects and negative implications for construction workers and organisations on the issue of construction site accidents are as follows: Workers and organisations experiencing of death, shock/trauma, nerve damages, cardiac arrest, muscular contraction, loss of income, body fracture, fatalities, legal expenses, strain, burns and cuts, back injuries, damage to plant and equipment, damaged to employer's reputation, payment of settlement for injuries and death, disruption of site operation, neurological disorder, disorder of the sensory function/reduction in tactile sensitivity, loss of manual dexterity, somewhat permanent neck and shoulder pain, cardiovascular disease, and joint damage are some of the key negative implications of construction site accidents during project delivery on sites. Hence, the study further concluded that some of key preventive measures and strategies to mitigate or reduce the major causes of construction sites are for construction workers and organisations ensuring that good maintenance and ensuring

good condition of equipment and tools, employment of qualified workers, effective health and safety training, the use of PPE when on construction site, effective communication to overcome issues of language barrier, effective usage of health and safety training, effective use of PPE during site operations, strict and consistent supervision by professionals during site operation, involvement of proper professionals at every stage of construction, adhering to regulations of building load, following the building approval before permission to construct building, ensuring that live load and dead load proper are calculated by professional structural engineers to prevent overloading, and investigation of soil bearing capacity before design of structure were effective measures towards reducing or mitigating issues construction sites in KwaZulu-Natal construction sector. Thus, this empirical study has significantly contributed to the body of knowledge on how construction organisations and their workers would be able to assess major causes and effects of construction site accidents and potential preventive measures and strategies towards effective management and mitigation of potential construction site accidents during project delivery in the KwaZulu-Natal construction sector.

5.6 Limitations of The Study

This research study experienced some challenges and limitations due to time and location constraints, as well as research respondents' rate of participation during data collection. The construction industry is known for being notorious for its time constraints and challenges in responding to research questionnaires, which are inherent to the nature of the industry. Thus, the respondents' rate in this study placed a limitation because response rates were relatively small in the South African context to generalise the findings. However, the key findings and subsequently the conclusions have significantly contributed to the body of knowledge on how key measures and strategies for the prevention of accidents, occupational injuries and related risks on construction sites in the KwaZulu-Natal, South African, construction industry.

5.7 Recommendations

Accordingly, the findings and conclusions presented in this study emanated from an empirical investigation of the major causes of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry and to proffer some of

the effective management strategies for the prevention of fatal construction accidents. Thus, the following key recommendations emerged, which are geared towards contributing to strategic insights on how to effectively identify, assess, and mitigate major sources of construction site accidents in South Africa, especially in the KwaZulu-Natal construction sector. Therefore, by implementing recommendations emanating from the key findings and conclusions among construction organisations and their stakeholders, proactive measures and strategies to identify and mitigate the major causes of construction site accidents in the KwaZulu-Natal construction sector will be facilitated. This will ultimately drive mitigation of potential construction site accidents and occupational injuries in the KwaZulu-Natal construction industry. Thus, based on this submission, the following recommendations are made for construction organisation and site workers accordingly:

- The construction organisations and site workers should endeavour to critically identify and assess construction sites' health and safety risks and potential accidents during project delivery in relation to falling object accidents, falling from heights and scaffolding accidents, electrocution, structure collapse accidents and crane and vibrating tool accidents. This approach would significantly assist in improving construction health and safety best practices in South Africa, especially in the KwaZulu-Natal construction sector.
- Construction organisations are encouraged to conduct comprehensive assessments of the health and safety implications emanating from construction site accidents in order to accurately account for and document resultant effects on site workers, the environment, and construction organisations. Thus, this approach will assist in keeping statistical records of actual data of construction site accidents and occupational injuries in the KwaZulu-Natal construction industry, and their related implications for construction organisations and their involved workers.
- Construction organisations in KwaZulu-Natal are recommended to establish and implement effective management strategies of industry standard for the prevention of construction site accidents and occupational injuries and fatalities.

5.8 Recommendations for Future Research Studies

The following recommendations are made for further research:

A research study seeking pragmatic strategies towards enhancing of overall construction occupational safety and health best practices; and

A further research study can explore the use of advanced and innovative technologies to enhance preventive strategies for occupational health and safety construction site accidents in the South African construction industry.

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15. On a scale of 1 (minor) – 5 (major) rate the causes of falling object accident on construction site. (Please note the 'Unsure' and 'Does not' Options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
15.1	Missing toe on scaffolding/kick boards on scaffolding	U	DN	1	2	3	4	5
15.2	Debris and materials falling from planks or loads while been lifted	U	DN	1	2	3	4	5
15.3	Holes in safety netting/gaps between perimeter safety screen	U	DN	1	2	3	4	5
15.4	Been blown from structures by wind	U	DN	1	2	3	4	5
15.5	Materials left at edges unsecured	U	DN	1	2	3	4	5
15.6	Workers working without any proper training and measure pat in place to control the occurrence of falling object accidents on site.	U	DN	1	2	3	4	5
15.7	Other:_____			1	2	3	4	5
15.8	Other:_____			1	2	3	4	5

16. On a scale of 1(minor) – 5 (major) rate the cause of fall from height accident on construction site. (Please note the 'Unsure' and 'Does not' Options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
16.1	Insufficient or lack of Training	U	DN	1	2	3	4	5
16.2	Weak planking	U	DN	1	2	3	4	5
16.3	Insecure bracing	U	DN	1	2	3	4	5
16.4	Overloading	U	DN	1	2	3	4	5
16.5	Ignoring safety rules (protocol)	U	DN	1	2	3	4	5
16.6	Incompetent erector	U	DN	1	2	3	4	5
16.7	Other:_____			1	2	3	4	5
16.8	Other:_____			1	2	3	4	5

17. On a scale of 1 (minor) to 5(major) rate the causes of Electrocution accidents on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
17.1	Contact with overhead power lines	U	DN	1	2	3	4	5
17.2	Contact with energized sources	U	DN	1	2	3	4	5
17.3	Improper use of extension and flexible cords	U	DN	1	2	3	4	5
17.4	Other:_____			1	2	3	4	5
17.5	Other:_____			1	2	3	4	5

18. Structure Collapse

- On a scale of 1 (minor) to 5(major) rate the causes of structure collapse on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
18.1	Brief and designs deficiencies	U	DN	1	2	3	4	5
18.2	Natural occurrence	U	DN	1	2	3	4	5
18.3	Substandard materials	U	DN	1	2	3	4	5
	Poor skilled labour	U	DN	1	2	3	4	5
	Excessive loading	U	DN	1	2	3	4	5
18.4	Other:_____			1	2	3	4	5
18.5	Other:_____			1	2	3	4	5

19. Crane Accident

On a scale of 1 (minor) to 5(major) rate the causes of crane accident on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
19.1	Poor communication	U	DN	1	2	3	4	5
19.2	Operators carelessness	U	DN	1	2	3	4	5
19.3	Poor work supervision	U	DN	1	2	3	4	5
19.4	Obstruction of vision	U	DN	1	2	3	4	5
19.5	Working in an Hazardous weather condition	U	DN	1	2	3	4	5
19.6	Tight working environment	U	DN	1	2	3	4	5
19.7	Unsanitary and unorganized working environment.	U	DN	1	2	3	4	5
19.8	Ignorance and working with a faulty crane	U	DN	1	2	3	4	5
19.9	Non compliance with safety measures stated while working with on the crane	U	DN	1	2	3	4	5
19.10	Unqualified operator operating the crane	U	DN	1	2	3	4	5
19.11	Failure of track and buffer of the crane	U	DN	1	2	3	4	5
19.12	Failure of loading Ropes	U	DN	1	2	3	4	5
19.13	Motorized and adjustable lifting system failure	U	DN	1	2	3	4	5
19.14	Overloading	U	DN	1	2	3	4	5
19.15	Use of component that does not fulfill the required technical specifications	U	DN	1	2	3	4	5
19.4	Other: _____			1	2	3	4	5
19.5	Other: _____			1	2	3	4	5

20. Vibrating tool Hazard

On a scale of 1 (minor) to 5(major) rate the causes of vibrating tool hazard on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
21.1	Strain	U	DN	1	2	3	4	5
21.2	Back injuries	U	DN	1	2	3	4	5
21.3	Fracture	U	DN	1	2	3	4	5
21.4	Burns and cut	U	DN	1	2	3	4	5
21.5	Fatalities	U	DN	1	2	3	4	5
21.6	Other: _____			1	2	3	4	5
21.7	Other: _____			1	2	3	4	5

21. Effects

On a scale of 1(minor) to 5(major) rate the effects of falling objects accidents on Construction Site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
21.1	Strain	U	DN	1	2	3	4	5
21.2	Back injuries	U	DN	1	2	3	4	5
21.3	Fatalities	U	DN	1	2	3	4	5
21.4	Fracture	U	DN	1	2	3	4	5
21.5	Burns and cut	U	DN	1	2	3	4	5
21.6	Fatality	U	DN	1	2	3	4	5
21.7	Legal expenses	U	DN	1	2	3	4	5
21.8	Other: _____			1	2	3	4	5
21.9	Other: _____			1	2	3	4	5

22. Fall from height

On a scale of 1 (minor) to 5(major) rate the effect of fall from height on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
22.1	Grinders	U	DN	1	2	3	4	5
22.2	Clipping hammer	U	DN	1	2	3	4	5
22.3	Rammers drills	U	DN	1	2	3	4	5
22.4	Chain saw	U	DN	1	2	3	4	5
22.5	Construction site	U	DN	1	2	3	4	5
22.6	Forest machine	U	DN	1	2	3	4	5
22.7	Graders	U	DN	1	2	3	4	5
22.8	Wheels	U	DN	1	2	3	4	5
22.9	Tractors	U	DN	1	2	3	4	5
22.10	Foot – list trucks	U	DN	1	2	3	4	5
22.11	Other: _____			1	2	3	4	5
20.12	Other: _____			1	2	3	4	5

23. Electrocution

On a scale of 1 (minor) to 5(major) rate the effect of electrocution on construction site. (Please note the 'Unsure' and 'Does not' options).

Factor	Unsure	Does not	MinorMajor				
			1	2	3	4	5
23.1 Damage of plants and equipments	U	DN	1	2	3	4	5
23.2 Payment of settlement for injuries & death	U	DN	1	2	3	4	5
23.3 Damaged reputation to the employer	U	DN	1	2	3	4	5
23.4 Disruption of site operator	U	DN	1	2	3	4	5
23.5 Cost of case litigation process	U	DN	1	2	3	4	5
23.6 Other: _____			1	2	3	4	5
23.7 Other: _____			1	2	3	4	5

24. Collapse of Structure

On a scale of 1 (minor) to 5(major) rate the effects of collapse of structure accident on the Construction Site. Please note the 'Unsure' and 'Does not' Options

Factor	Unsure	Does not	MinorMajor				
			1	2	3	4	5
24.1 Loss of profit	U	DN	1	2	3	4	5
24.2 Permanent and non – permanent disability	U	DN	1	2	3	4	5
24.3 Death	U	DN	1	2	3	4	5
24.4 Injuries	U	DN	1	2	3	4	5
24.5 Loss of time	U	DN	1	2	3	4	5
24.6 Other: _____			1	2	3	4	5
24.7 Other: _____			1	2	3	4	5

25. Crane accidents

On a scale of 1 (minor) to 5(major) rate the effect of crane accidents on construction site. (Please note the 'Unsure' and 'Does not' options).

Factor	Unsure	Does not	MinorMajor				
			1	2	3	4	5
25.1 Cardiac arrest	U	DN	1	2	3	4	5
25.2 Shock	U	DN	1	2	3	4	5
25.3 Severe burns	U	DN	1	2	3	4	5
25.4 Fracture	U	DN	1	2	3	4	5
25.5 Death	U	DN	1	2	3	4	5
25.6 Nerve damages	U	DN	1	2	3	4	5
25.7 Muscular contraction	U	DN	1	2	3	4	5
25.8 Been blow away from contact e.g. circuit	U	DN	1	2	3	4	5
25.9 Other: _____			1	2	3	4	5
25.10 Other: _____			1	2	3	4	5

26. Vibrating tool Hazardous

On a scale of 1 (minor) to 5(major) rate the effect of vibrating tool hazardous on construction site. (Please note the

Factor	Unsure	Does not	MinorMajor					'Unsure' and 'Does not' options).
			1	2	3	4	5	
26.1 Hazard identification	U	DN	1	2	3	4	5	
26.2 Safety regulation and strict enforcement	U	DN	1	2	3	4	5	
26.3 Personal protective gears	U	DN	1	2	3	4	5	
26.4 Safety officers	U	DN	1	2	3	4	5	
26.5 Welfare	U	DN	1	2	3	4	5	
26.6 Training	U	DN	1	2	3	4	5	
26.7 Language barrier	U	DN	1	2	3	4	5	
26.8 Other: _____			1	2	3	4	5	
26.9 Other: _____			1	2	3	4	5	

27. On a scale of 1(minor) to 5(major) rate the preventive measures agent falling object accident on Construction Site. (Please note the 'Unsure' and 'Does not' Option).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
27.1	Training	U	DN	1	2	3	4	5
27.2	The use of PPE	U	DN	1	2	3	4	5
27.3	Good maintenance and ensuring good condition of equipment and tools	U	DN	1	2	3	4	5
27.4	Qualified workers	U	DN	1	2	3	4	5
27.5	Language barrier	U	DN	1	2	3	4	5
27.6	Other: _____			1	2	3	4	5
27.7	Other: _____			1	2	3	4	5

28. On a scale of 1(minor) to 5 major rate the preventive measures against fall from Height and Scaffolding accidents on the Construction Site. (Please note the 'Unsure' and 'Does not' option).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
28.1	Neurological disorder	U	DN	1	2	3	4	5
28.2	Disorder of the sensory function/ reduction in factice sensitively	U	DN	1	2	3	4	5
28.3	Loss of manual dexterity	U	DN	1	2	3	4	5
28.4	Neck and shoulder pain	U	DN	1	2	3	4	5
28.5	Cardiovascular disease	U	DN	1	2	3	4	5
28.6	Joint damage	U	DN	1	2	3	4	5
28.7	Other: _____			1	2	3	4	5
28.8	Other: _____			1	2	3	4	5

29. Electrocution Accidents

- On a scale of 1 (minor) to 5(major) rate the preventive measure against electrocution accidents on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
29.1	Regulations of building load	U	DN	1	2	3	4	5
29.2	Building approval before permission to construct building	U	DN	1	2	3	4	5
29.3	Investigation of soil bearing capacity before design of structure.	U	DN	1	2	3	4	5
29.4	Involvement of proper professionals at every stage of construction	U	DN	1	2	3	4	5
29.5	Live load and dead load proper calculation by structural engineers to prevent overloading	U	DN	1	2	3	4	5
29.6	Strict and consistent supervision by professionals	U	DN	1	2	3	4	5
29.7	Other: _____			1	2	3	4	5
29.8	Other: _____			1	2	3	4	5

30. Collapse of accidents

- On a scale of 1 (minor) to 5(major) rate the preventive measure against collapse of accidents on construction site. (Please note the 'Unsure' and 'Does not' options).

	Factor	Unsure	Does not	MinorMajor				
				1	2	3	4	5
30.1	Maintaining a safe distance from overhead power	U	DN	1	2	3	4	5
30.2	Use ground fault circuit interrupter (GFCI)	U	DN	1	2	3	4	5
30.3	Inspects extension cords and portable tools for opening that could lead to transmission of electric current before use	U	DN	1	2	3	4	5
30.4	Use power tools and equipments as instructed by designer	U	DN	1	2	3	4	5
30.5	Follow tag out procedures or lockout Procedure	U	DN	1	2	3	4	5
30.6	Use overhead power line distance warning device for heavy equipments and vehicles such as trucks, crane and so on.	U	DN	1	2	3	4	5
30.7	Avoid working in the rain until its sats to return is work in areas where there is close proximity to electricity	U	DN	1	2	3	4	5
30.8	Other: _____			1	2	3	4	5
30.9	Other: _____			1	2	3	4	5

31. CRANE ACCIDENTS

On a scale of 1 (minor) to 5(major) rate the preventive measure against crane accidents on construction site.
(Please note the 'Unsure' and 'Does not' options).

Factor	Unsure	Does not	MinorMajor				
			1	2	3	4	5
31.1 Communication barrier avoidance	U	DN	1	2	3	4	5
31.2 Licensed and qualified operator	U	DN	1	2	3	4	5
31.3 Constant supervision	U	DN	1	2	3	4	5
31.4 Making use of sign boards & communication boards	U	DN	1	2	3	4	5
31.5 Environmental factor such as workers in a good and organized working environment	U	DN	1	2	3	4	5
31.6 Safety managements	U	DN	1	2	3	4	5
31.7 Overloading	U	DN	1	2	3	4	5
31.8 Other: _____			1	2	3	4	5
31.9 Other: _____			1	2	3	4	5

32. Vibrating Tool Hazards

On a scale of 1 (minor) to 5(major) rate the preventive measure against vibrating tool hazards on the construction site. (Please note the 'Unsure' and 'Does not' options).

Factor	Unsure	Does not	MinorMajor				
			1	2	3	4	5
32.1 Selecting or buying a low vibrating tool	U	DN	1	2	3	4	5
32.2 Maintaining tools properly	U	DN	1	2	3	4	5
32.3 Proper grip and right handling technique to reduce vibration	U	DN	1	2	3	4	5
32.4 Use of gloves and protective clothing	U	DN	1	2	3	4	5
32.5 Training	U	DN	1	2	3	4	5
32.6 Regular driving surface	U	DN	1	2	3	4	5
32.7 Seats should have proper vibration absorption material in case of whole body vibration from vehicles.	U	DN	1	2	3	4	5
32.8 Other: _____			1	2	3	4	5
32.9 Other: _____			1	2	3	4	5