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**EXAMINING HEALTH AND SAFETY THROUGH THE LEAN  
THINKING LENS: THE CASE OF THE NIGERIAN CONSTRUCTION  
INDUSTRY**

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**BSc, MSc, PGr**

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements  
for the degree of Doctor of Philosophy

The University of Huddersfield

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## Abstract

Health and safety issues in construction are a major source of concern across the world. Dealing with accidents and their aftermaths has a significant impact for construction firms as the prevention of such issues protects lives of workers and enhances efficiency and performances. In the Nigerian construction industry, this issue is even more substantial because many indigenous construction firms operating in the country do not value and prioritise risks and health and safety. As a result, accidents occur unnecessarily, which have a negative impact on the overall firms' performance. Although the application of lean theory has been found to improve construction safety in other parts of the world, in Nigerian safety research, this problem has not been addressed fully and there is no safety framework available for accident prevention. The central aim of this research is to investigate how the adoption of lean practices can be the foundation for a safety system in the Nigerian construction industry.

To this end, the thesis contains an extensive literature review on sociotechnical systems theory, being the umbrella theory adopted in this study to understand the problems associated with construction safety and explore how risks can be mitigated using lean practice. The thesis further focuses on three lean construction techniques: the 5S Methodology, Visual Management and the A3/PDCA and their deployment. The goal is to apply these tools to develop a lean safety framework that construction firms in Nigeria can make use of to mitigate accidents and their root causes.

A qualitative study was conducted applying multiple case study design. In total, twenty-seven semi-structured interviews and non-participant observations were used to collect data from six indigenous construction companies in Nigeria: three small-scale and three medium scale companies. The collected data were thematically analysed.

The study found five major root causes of accidents in the Nigerian construction industry: (i) lack of information, knowledge, and training; (ii) inability to identify or recognise hazards/unsafe conditions in the worksite before the start of tasks; (iii) identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition; (iv) management failure to provide safe work environment; and (v) negative behaviour and attitude towards safety by workers. The study also found that the 5S methodology, visual management and the A3/PDCA can be implemented in a safety system to mitigate accident root causes. This led to the development of a Lean Safety Framework (figure 10).

Thus, the study has established that by providing a Lean Safety Framework (LSF), construction firms can improve health and safety performance and minimize the risks. Along with the developed framework, recommendations are provided for its use. This research makes two core contributions. It has contributed to theory development by expanding the use of sociotechnical systems theory, and by using the theory to detail how lean practice can be applied in safety systems to mitigate accident root causes in construction. It has contributed to the practice of lean and safety in Nigerian construction by developing a Lean Safety Framework that construction firms in the country can make use of to improve safety performance and save lives.

## **1. Chapter One – Introduction**

This thesis examines major health and safety issues, particularly accidents and their root causes in the Nigerian construction industry through a sociotechnical system theoretical lens (Longeni et al., 2013; Kleiner et al., 2015; Carayon et al., 2015). In particular, lean practice is the dominating theory that helps explore and examine how the accidents can be mitigated through a clear identification of the root causes (Salem et al., 2005; Tezel et al., 2009; Bajjou et al., 2017). Within the available tools in lean practices, this study mainly focusses on three lean construction tools, specifically the 5S, Visual Management and the A3/PDCA Problem Solving framework as tools to be used for the development of a conceptual lean framework to allow organisations to mitigate hazardous practices.

These tools have been chosen from other lean tools specifically because the use of the 5S and visual management is majorly channelled towards achieving a safe and visual workplace within organisations, which helps with accident prevention on site in construction process thereby reducing waste. While the A3/PDCA problem solving framework are continuous improvement tools applied for identifying and diagnosing the root causes of problems, this include accident root causes. For example, in context, slips, trips and falls are classed as some of the most common causes of accidents in the construction industry (Leino et al. (2014). First, the 5S is one of the most efficient working tools of the lean family that helps organisations achieve tidiness through its step by step housekeeping process (sort, set in order, shine, standardize and sustain), which helps eliminate slips, trips and falls and other accidents (Agrahari et al., 2015). Second, the Visual Management tool helps to increase transparency in the workplace through use of visual signs like notice boards, slogans, cards, indication lights, danger signs (Tezel et al., 2015) etc. In a construction site, visual management would help warn workers of potential danger by making abnormalities visible, keep employees in contact with the realities of their work environment, and help keep an orderly workplace so that accidents can be prevented (Koskela, 1992; Tezel et al., 2015). Visual management and the 5S works together to organize the workplace, making it safe for workers (Syed, 2012). Third, the A3/PDCA problem solving framework is a continuous improvement tool applied for the management of organisations. It helps to identify root causes of problems through a methodological application of the plan, do, check, act, in the A3 report. The A3 report is a document that contains the result from the PDCA. This framework supports the 5S and visual management by helping to discover where

problems occurs when they occur and helps to provide counter measures to address these problems (Shoot, 2008).

## **1.1. Problem Statement**

Workplace safety is an important aspect of everyday life for every employee irrespective of the industry one is employed in. Globally, workers suffer from workplace illness and accidents leading to serious injuries and death every day as they go about their jobs (Pinto et al., 2011; Ahmed et al., 2018). Although some industries are more death, injury, and illness prone than others, one of the most vulnerable and hazardous among industries is the construction industry (Zhou et al., 2015). Every year on site, about 108,000 construction workers are killed due to one form of accident or the other, and constructions workers are 3 to 4 times more likely to die from accidents than workers in any other industry (ILO, 2015). According to Walter (2018), the death and injury rate from construction is very high and alarmingly continues to rise. Hence, the industry has been considered the most hazardous industry in many parts of the world (Chi et al., 2005; Mehta & Theodore, 2006; Nadhim et al. 2016). There are many reasons that account for this poor health and safety record in construction, which include; diversity and complexity of the job, temporary and transitory nature of construction workplaces and the construction workforce (Kines, 2001); the unique nature of the working environment (Brace et al. 2009); the dangerous nature of construction job itself consisting of many dangerous activities, and incoherent working system (Snashall, 2005); abominable environment (Zou et al. 2007); increasing sociotechnical complexity of contemporary work environment (Robertson et at., 2015); variability and degree of uncertainty (Haris & McCaffer, 2013); work at height, complicated on-site plant machinery and equipment, workers attitude and behaviour towards safety (Finneran & Gib, 2013); culture of workers (Sousa et al., 2014).

The serious hazardous nature of the industry brings about negative impact on the overall performance of construction employees and even the companies they work for as compensations would be paid to accidents victims, treatment of those involved would be paid for, machines and equipment will be repaired or repurchased, money is spent in recruiting replacements, overtime cost spent for the work to be completed by others, thereby resulting in the companies making a loss in profit than making profit (Oxenburgh & Marlow, 2005; Jallon

et al. 2011; Yin et al., 2018). Workdays are lost, and work rate reduced due to the consequence of this (Zainon et al., 2018). These all lead to direct and indirect cost to all parties involved.

Despite this, the construction industry is a very lucrative and important industry, contributing massively towards the Gross Domestic Product (GDP) of countries across the world in terms of economic value. The construction industry is the second largest major source of employment worldwide, employing about 7% of the world's workforce (Spooner & Hopley, 2011; Zhou, Goh, & Li, 2015). Socially, construction stands as one of the first businesses that was developed by mankind and continues to shape the daily life of humankind in unique ways (WEF, 2016). Importantly, all other businesses look to the construction industry to provide and maintain their accommodations, plants and infrastructures thereby making construction a determinant of where and how we all live, work and play. Research has it that averagely, about 90% of people's time is spent indoors (Klepeis, 2001; Walden, 2018). Therefore, the building and the materials used for the construction and finishing of the building have a major impact on the health and well-being of those building and occupying them (WEF, 2016). Economically, the industry generates an annual revenue of almost \$10 trillion and added value of \$3.6 trillion, and accounts for about 6% of global GDP according to a report by World Economic Forum (WEF, 2016). In developed countries, construction accounts for around 5% of total GDP, and more than 8% of GDP in developing countries (WEF, 2016). It has been estimated that in 2030 the global construction market will grow by \$8trillion (Global Construction Perspectives, 2018).

Therefore, based on the social and economic importance of the construction industry to a country, and the many risks the industry poses to workers (WEF, 2016; Ahmed et al., 2018), it is imperative and of paramount importance that health and safety problems facing workers in the industry should be investigated and safety framework developed to mitigate these problems. The reason for this is that such safety frameworks would help prevent accidents, improve working conditions, help organizations achieve performance excellence and save cost. The cost emanating from construction injuries has been stated to have a substantial impact on the financial success of construction firms and increase the cost of construction by up to 17% (Hallowell, 2011). Creating a safety framework would therefore help these problems to be effectively managed within construction sites (Wachter & Yorio, 2014).



## 1.2. Theoretical Lens and Focus

Continuous efforts have been made through research to promote construction safety both within the research community (Laukkanen, 1999; Choudhry et al. 2007; Pinto et al., 2011; Zhou et al., 2015; Mohammadi et al., 2018), and from the government (HSE, 2002; HSE, 2004; European Commission, 2017). Due to these efforts, there has been a decrease in the trend of construction accidents, although continuous efforts remain imperative (Huang & Hinze, 2006; Halowell, 2012; Robertson et al., 2015).

From the research community, Laukkanen (1999) focused on training in occupational health and safety in the construction sector. Choudhry et al. (2007) reviewed literature on safety culture, emphasising that organizations should pay attention to safety culture to eliminate injuries, save lives and advance towards zero incidents. Authors developed a conceptual model of construction safety culture which construction firms can make use of to maintain and improve construction site safety. The model helps to measure safety culture within construction site environment. Pinto et al. (2011) focused on traditional management methods relating to occupational risk assessment in construction safety and outlined the major limitations of these methods to deal with construction safety. Zhou et al. (2015) noted that research on safety have focused on safety culture, safety competence, accident statistics, and design for safety. However, as Zhou et al. (2015) would state, it is difficult for stakeholders to have an overview of the field due to the large number of construction safety studies available with variety of topics. A systematic review of past studies identified three groups of safety research (Zhou et al., 2015). The first group is conducted from the angle of safety management process like safety assessment, safety training, and safety knowledge and safety measures. The second group focused on site workers and explored the impact of individual and group characteristics in relation to construction safety, here focus was on worker behaviour, perception, and safety climate. The third group made use of incident and accident data to promote construction safety and improve performance.

Guo et al. (2016) developed and tested an integrative construction workers safety behaviour model focusing on unsafe behaviours on site. Some other studies have focused their attention on exploring accident root causes looking at both the unsafe behaviours of workers and unsafe work environments. Some of these researchers like Heinrich (1931) proposed the Domino Theory in which accident is understood to happen due to the linear outcomes of unsafe conditions and unsafe act of workers. Heinrich stated that 88% of accidents that happen are

preventable accidents caused by workers working in unsafe manners. This traditional view has led to the understanding that the causes of accidents are due to forgetfulness by workers, lazy attitude, incompetence, and not paying attention, which are classed as human error (Guo et al., 2016). This position resulted in accident prevention strategies mainly focusing on eliminating unsafe behaviours. This view was however criticized as leading to a blame culture and for oversimplifying accident causation processes (Guo et al., 2016). Further, safety research shifted towards investigating the effects of organizational factors on accidents (Guo et al., 2016). The work of Reason (1997) comes into light here where he proposed the Swiss Cheese Model (SCM) used for risk analysis and risk management. The Swiss Cheese Model listed four failure domains: organisational factors, supervision, preconditions, and specific acts, and claims that accidents can be traced to one or more of these domains (Guo et al., 2016). Consequently, Abdelhamid & Evereth (2000) developed the Accident Root Cause Tracing Model (ARCTM). This model, which encompasses the further development of other models such as the domino theory and human factor theory was developed to provide accident investigators with a model that can be easily used to investigate and identify accident root causes (Abdelhamid & Evereth, 2000). After testing the model on three road construction accidents, Abdelhamid & Evereth (2000) proposed that accidents occur due to three root causes: failure to identify an unsafe condition that existed before an activity was started or that developed after an activity was started; deciding to proceed with a work activity after the worker identifies an existing unsafe condition; deciding to act unsafe regardless of initial conditions of the workplace.

Despite these efforts, the problem persists as the industry is still plagued with fatalities (Zhou, Goh, & Li, 2015; Walter, 2018). A report by Institute of Occupational Safety and Health (IOSH) stated that 475 work-related accidents happen per minute in construction. Against the backdrop of such imperative, this research will consider the three root causes stated by Abdelhamid & Evereth (2000) and examine if the same can be stated to reflect what the root causes are in the Nigerian Construction Industry with the aim of producing a lean health and safety framework that construction organisations can make use of to detect these root causes 'before' they lead to actual accidents. The lean safety framework to be developed in this research is different from the Accident Root Cause Tracing Model by Abdelhamid & Evereth (2000) in the sense that while the ARCRM is an 'after the accident' template applied to systematically investigate why an accident has happened 'after' the accident has happened, the lean framework to be developed for this research will help detect and eliminate hazards in the workplace 'before' they lead to actual accidents.

Therefore, to achieve the goal of developing this lean safety framework, the research employs the sociotechnical systems theory as an overarching theoretical ground to understand and explain the problem associated with health and safety regarding accidents and their root causes and how these root causes can be mitigated using lean practices. Baxter & Sommerville (2011) defines sociotechnical systems as “an approach that considers human, social, and organisational factors, as well as technical factors in the design of organisational systems”. Previous research by Carayon et al. (2015) noted the insufficiency of traditional efforts in dealing with workplace safety, stating that these methods only deal with the individual without taking the broader sociotechnical aspect of the environment surrounding the workers into perspective. Carayon et al. (2015) therefore suggested that focus should be placed on the broader context of work, namely, the social, organisational and the technical environment. The sociotechnical systems theory is therefore being applied in this research due to the complex nature of health and safety issues that consist of multiple facets as demonstrated in the previous paragraph. The sociotechnical perspective provides a theoretical frame for bringing about a more holistic, fine-grained picture of the problem under study.

With sociotechnical systems theory, the work environment is seen as comprising of both a social organisational part, which comprises of the people, the organization, and social work environment, and a technical part, which comprises of the work tools and work systems. The objective of sociotechnical system theory is the joint optimization of both sub-systems (social and technical). The theory stipulates that for optimal performance, both parts; social (human systems) plus technical (non-human systems) must be jointly optimized to work together. Therefore, when technical systems are introduced in organisations, human needs must not be left aside. Both sub-systems must whenever possible be given equal attention (Mumford 2006). According to Robertson et al. (2015) the sociotechnical systems perspective provides valuable insights into the problems associated with workplace safety. Hence there are a growing number of researchers (e.g. Wilson, 2014; Carayon et al., 2015; Waterson et al., 2015), who are turning to system-based approaches to workplace safety focusing on examination of the interactive influences of social-organisational and technical aspect of the work environment (Robertson et al., 2015). Because construction involves people making use of various complex work tools and systems in their everyday jobs, in very dangerous changing social environments, it will be important that in providing a safety system, the systems look beyond traditional method and must take into consideration both the social, organisational and technical aspect of the job and work environment. This study therefore takes the position of Carayon et al. (2015) into

consideration by employing the sociotechnical system theory as a management theoretical lens in dealing with workplace safety to place focus on a broader context of work, namely the social, organizational and technical environment.

The existence of a relationship between elements of sociotechnical systems theory and lean production was found (Dabhilkar & Ahlstrom, 2013). It was discovered that better plant performance is achieved when elements of sociotechnical systems theory and lean production are implemented together as against implementing one in isolation of the other (Dabhilkar & Ahlstrom, 2013). Accordingly, Shaw & Ward (2007) defined “lean as an integrated sociotechnical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability”. Consequently, Longoni et al. (2013) investigated the impact of lean on operational health and safety performance and highlighted the need for both the technical and social components of lean (sociotechnical components) to be present for lean to have positive operational, and health and safety impacts.

Within the sociotechnical systems framework, lean thinking provides complementary range of practices and tools for understanding how workplace safety can be improved. Lean stems from the production management principles of lean production, which is a management philosophy that came from the Toyota Production System (Womack, Jones, & Roos, 1990). It was introduced into construction by Koskela (1992) and named lean construction. Salem & Zimmer (2005) defined lean construction as “the continuous process of eliminating waste, meeting or exceeding all customers’ requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project”. The adoption of lean construction approaches in some developing countries according to Koskela & Leikas (1994) has shown significant success in addressing the issue of waste in construction. Poor safety, which leads to accidents, has been considered as waste in lean construction. The reason for this is that the cost of injury is high as it involves not only human sufferings but also medical treatment of victims, payment of compensations, loss of income, repair of damages, victim’s lost time, hours spent on changing work routines, capital cost from lost productivity, investigations, insurance, cost of safety measures, etc. (Kjellen, 2000; Nahmens & Ikuma, 2009; Leino et al., 2014).

The relationships between lean and health and safety in construction have been established through research (Ghosh & Young-Corbett, 2009). For example, Leino et al. (2014) after identifying slips, trips, and falls on same level as the largest cause of accident in a Finnish construction company launched the 5S to improve the safety performance in the company. The

study revealed that safety performance improved significantly due to the application of the 5S process. This relationship is well established in literature (Salem et al., 2005; Nahmens & Ikuma, 2009; Tezel et al., 2009; Bajjou et al., 2017; Dehdasht et al., 2018). These studies demonstrate the success stories of the application of lean construction tools in improving construction safety. However, question may arise as to why the results from these studies cannot be applied in Nigeria. Different countries have their own different peculiarities regarding implementation barriers, which has been found to be the major problem with successful implementation of lean techniques (Ballard & Kim, 2007; Sarhan & Fox, 2013; Bamford et al., 2015; Bayhan et al., 2019). These implementation barriers may include cultural issues, lack of training, lack of leadership, resistance to change, lack of education, lack of commitment to change and innovation, insufficient knowledge, government issues (Wandahl, 2014; Bayhan et al., 2019). These implementation barriers may hinder the results from these studies from being successfully applied in Nigeria.

### **1.3. Research Aim, Question and Objectives**

Having taken all the implementation barriers highlighted in the previous section into consideration, this study aims to investigate how the adoption of lean practices can be the foundation for a safety system in the Nigerian construction industry.

The Nigerian construction industry is a large employer of labour with a great proportion of its working population employed in the industry. However, the death and injury rate from construction in developing countries like Nigeria has been found to be even higher than it is in the developed economies (Idoro, 2004, Idoro, 2007; Olutuase, 2014). Various studies have been conducted about the health and safety issues in the Nigerian construction industry. A majority of these studies have focused on the areas of regulations (Idoro, 2008; Umeokafor et al., 2014); health and safety performance (Olatunji et al., 2007; Okoye, 2016; Izobo-Martin et al., 2018); safety culture (Belel & Mahmud, 2012); safety and quality issues (Owueleka, 2013); health and safety management (Idoro, 2011; Agbede et al., 2016), effect of mechanisation on occupational health and safety (Idoro, 2011); assessment of safety climate (Okoye & Aderibigbe, 2014); artisan working condition in Nigerian construction (Abdullahi et al., 2015); inadequate safety measures (Udo et al., 2016); causes and effects of accidents on construction sites (Kadiri et al., 2014), building collapse (Ede, 2010; Agwu & Olele, 2014); assessment of

cost impact in health and safety on construction projects (Muhammad et al., 2015); ensuring safe working environment (Olatubi & Olatubi, 2017), investigation into public and private clients attitude, commitment and impact on construction health and safety (Umeokafor, 2018).

While these studies identify some of the issues facing health and safety in the Nigerian construction industry, the studies only suggest recommendations. First to improve health and safety, government should come up with new health and safety legislations with enforcement of the legislations taking off at the local level (Adeyemo & Smallwood, 2017). Second, government should recruit more health and safety inspectors and organisations should adopt self-regulating style of enforcement and champion health and safety enforcement (Umeokafor et al., 2014). Third, strong safety culture should be incorporated in construction sites by organisations and training must be provided for new employees (Belel & Mahmud, 2012). Fourth, organisations should make structures available for managing health and safety and make use of risk management plans in identifying risks associated with jobs (Idoro 2008; 2011).

These studies have not addressed the issue of creating frameworks for accident prevention. However, Okoye (2016) developed a social ecological model of safety performance improvement (SEM-SPI) framework and recommended that to improve safety performance in the Nigerian construction industry, the framework should be practically applied. This framework, which is based on the ecological systems theory only focuses on modelling the behaviour of construction workers towards behaving safely while on site. While this study is a step forward towards improving safety performance in the Nigerian construction industry, it does not cater for the tools and techniques that construction organisations can implement to eliminate accidents on site. Hence it has been stated by Williams et al. (2018) that there is no safety framework available for preventing accidents in Nigeria. This study will cover this gap by creating a lean accident prevention framework, which incorporates the 5S, visual management and the A3/PDCA problem solving framework as lean tools that can be used for accident prevention on site.

Based upon the above knowledge gap, the present research argues that a natural outcome of lean construction idea of waste would be the safeguarding of construction workers, thereby preventing accidents from occupational health and safety hazards in the workplace. Therefore, the lean construction tools can improve safety performance by decreasing the occurrence of

accidents that harm the workers. This research therefore puts forth the following research question.

*How can the adoption of lean practices be applied in a safety system to mitigate accident root causes in the Nigerian Construction Industry?*

To answer the research question, the following objectives have been formulated:

1. Investigate the root causes of construction accidents in the Nigerian Construction Industry.
2. Explore how and to what extent lean tools such as the 5S, Visual Management, and the A3/PDCA can be used to mitigate these root causes.
3. Develop a conceptual lean framework to allow organisation to diagnose and improve health and safety performance.

Since the aim of the research is to find out how the adoption of lean practice be the foundation for a safety system in the Nigerian construction industry, it is important that the research question addresses both the root causes of accidents in the Nigerian construction industry and lean construction safety tools that can help lay the foundation for a safety system. This is because through understanding these lean construction safety tools, and understanding the root causes of accident in the industry, the lean safety tools can be channelled towards addressing the identified root causes and therefore a lean safety framework can be created to mitigate these accident root causes.

Therefore, the three objectives listed above points the readership to a road map on how the research question will be answered.

The first objective was carried out to investigate and identify the root causes of construction accidents in the Nigerian construction industry. The study identified five major root causes of accidents as follows: (i) lack of information, knowledge, and training; (ii) inability to identify or recognise hazards/unsafe conditions in the worksite before the start of tasks; (iii) identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition; (iv) management failure to provide safe work environment; and (v) negative behaviour and attitude towards safety by workers.

The second objective was carried out to explore how to and to what extent these lean tools: 5S, Visual Management and A3/PDCA can be used to mitigate the above identified root causes. This is important because without knowing the root causes of accidents in the industry, it would be impossible to know if the lean tools highlighted in objective two can be used to mitigate

them. Having investigated these tools comprehensively, the study found that the above named lean safety tools can all individually contribute towards mitigating the identified accident root causes in this study, and can be combined in a single safety system as a safety framework to mitigate the identified root causes.

Objective one and two are important because the answers derived from both led to the formulation of objective three, which was to develop a conceptual lean framework to allow organisations to diagnose and improve health and safety performance. This was achieved by creating the Lean Safety Framework (LSF) in figure 10. Thus, answering the research question set up for the study.

## **1.4. Contributions and Novelty of Research**

It has been suggested that contribution should be highlighted in the introductory pages of research papers (Nicolson et al., 2018). This research makes contribution to both theory and to practice respectively applying Nicolson et al (2018) gap spotting method.

### **1.4.1. Contribution to Theory**

Despite the various body of research that has investigated safety in construction with end goals of creating solutions to end the scourge of accidents in the industry, accidents still occur. While it is safe to say that research will continue to look for ways to end this dilemma, it is evident that conventional efforts in dealing with workplace safety are insufficient in accident prevention, and the body of knowledge is in need of a framework that deals with this serious issue to close the gap. A major reason for this insufficiency has been that these efforts focus more on the individuals and does not take the broader sociotechnical aspect of the work environment into perspective. It was therefore advised that focused be placed on the broader context of work such as the social and organisational aspect of the work environment and the technical aspect (Carayon et al., 2015). Hence this study incorporated the sociotechnical systems theory as a theoretical lens to investigate this issue. By applying the sociotechnical systems theory, the author was able to develop a more holistic, fine-grained lean safety framework (LSF) that provides greater insights into workplace safety, taking the broader social, organisational, and technical aspect of the construction work environment surrounding the workers into perspective. This study has helped in covering the gap created by conventional



methods identified in this study by focusing on not only the individuals but also on the work environment, and tools and techniques the individuals make use of to stay safe while carrying out their construction activities on site, and also by creating a safety framework (see figure 10) for this purpose. Thus, the study has shown that by applying the sociotechnical systems theory to harmonize the social, organisational, and technical aspects of the construction workplace, accident root causes can be mitigated and therefore, health and safety can be improved to a great extent. This is consistent with the sociotechnical systems theory discussed in chapter 2 (Mumford, 2006). Furthermore, the study developed and presented a framework (LSF) based on the sociotechnical theoretical lens, supported by case study interviews and non-participant observations. Therefore, this study has expanded the use of sociotechnical systems theory by using the theory to detail how lean practice can be applied in safety systems to mitigate accident root causes in construction and providing a framework (figure 10) that explains how this can be achieved.

#### **1.4.2. Contribution to Practice**

While there have been studies in Nigeria focusing on improving health and safety in construction, it is noteworthy to state here that such focus has never been centred on lean. Being a profit maximization and waste elimination technique, lean through some of its tools and technique have the potential to improve health and safety in the country's construction industry if applied as this study has established through the LSF development. This is not to say that lean has not been applied in construction and other fields in the country even though the concept is new to the country. Authors like Adamu et al. (2012) and Ahiakwo et al. (2013) have implemented the Last Planner System (LPS) for improvement of construction practice in the country. However, no prior studies on lean in a Nigerian context have investigated how lean can be used to prevent accidents and unsafe practices in the construction industry to the knowledge of this researcher. Therefore, this research covers this gap by taking the first step to contribute to the practice of lean construction and health and safety in Nigerian construction. This has been achieved by the development of the practical Lean Safety Framework (figure 10) for organisations to make use of in improving their health and safety performance.

This framework is important for construction firms and in construction safety research in the country for several reasons. First, previous research has shown that safety research in the

Nigerian construction industry lack available framework for accident prevention (Williams et al., 2018). This study has provided a framework through development of the LSF to cover this gap in the construction safety research body of knowledge in Nigeria. Thus, safety research in the country will benefit from this study as the study will be useful for the authors of academic journals, conference papers, and for both undergraduate and post graduate researchers in the country. It will also be useful to undergraduate and post graduate researchers outside the country writing papers on construction safety in Nigeria.

### **1.4.3. Novelty of the Study.**

This study is novel in the following fronts. Firstly, the research represents the first study in Nigeria safety research to investigate how the adoption of lean can be applied in a safety system to mitigate accident root causes in the Nigerian construction industry. This is based on the call for adoption of lean strategies to improve safety performance in Nigerian construction by Zuofa & Ochieng (2015).

Second, the study is the first study in Nigerian safety research to develop a safety framework for the Nigerian construction industry, using a combination of three lean construction tools identified in (figure 10) as the Lean Safety Framework for the purpose of improving health and safety performance.

For the lean safety research community, this research also stands as one of the studies to combine the 5S, Visual Management, and the A3/PDCA Problem Solving Framework in a single safety framework for accident prevention.

## **1.5. Structure of the Thesis**

Overall, the study consists of six chapters:

Chapter one introduces the research by broadly presenting the background to the research, the theoretical lens and focus, the research aim, question, and objectives and ends with the research contributions and novelty of the study.

Chapter Two establishes and reviews the literature for the study. It starts by presenting the research conceptual framework. It then discusses the sociotechnical systems theory and its

applications and establish why the theory was chosen for the study. The chapter then proceeds with a discussion on the Nigeria profile, accessing global health and safety practice in construction, the Nigerian construction industry, the state of health and safety in the Nigerian construction industry, including a brief view into details of some construction accidents in the country, and aspirations for health and safety in the construction industry. The chapter continues with a discussion on the root causes of accidents in the construction industry looking at several body of literature. Then the chapter dives into lean thinking body of knowledge discussing lean construction, lean tools and techniques and their implementation barriers. The chapter ends with discussions on the three lean construction applied in this study.

Chapter Three presents the research methodology applied for the study. It started with a discussion of the research context, then proceeds to the research philosophy where the ontological and epistemological stance for the research were chosen. It also discussed axiology, the qualitative research approach, which is the approach for the study, inductive and deductive reasoning, including the case study design. It also discussed the interview method, the theoretical sampling, the data collection method, reliability, and validity and ends with a brief discussion on ethics.

Chapter Four presents the findings of the research and presents these based on the different themes generated during the coding stage and ends with a cross case analysis.

Chapter Five discusses the results from the findings using the objectives of the study as a structure, Then continues by developing a lean safety framework, which the study aimed to achieve and ends with a discussion on implications for existing and future national, and organisational policy.

Chapter Six presented a summary review of the main objectives of the study, the main findings of the study, and provides recommendations. Furthermore, the chapter presents the research contributions and theoretical and practical implications, research limitations and ends with a discussion on future research and reflective commentary.

## **2. Chapter Two – Literature Review**

This chapter of the thesis presents a literature review on the relevant areas being investigated in this study. The major issue under investigation in this study is health and safety in construction, specifically accidents and their root causes in the Nigerian construction industry. This is a huge problem in construction all over the world due to the many deaths and injuries resulting from the accidents happening in the industry day in, day out. While there have been many safety studies aimed at mitigating these problems in the workplace (Heinrich, 1931; Laukkanen, 1999; Abdelhamid & Evereth, 2000; Choudhry et al., 2007; Pinto et al., 2011; Guo et al., 2016), the problem persists (Zhou, Goh, & Li, 2015; Walter, 2018). In developing countries like Nigeria, the problem is exacerbated to a large extent. Many studies conducted into this issue in the country do not deal with the cause, rather, they just highlight some of the reasons and proffer recommendations on how the issues can be mitigated without solutions. In the bid to enhance safety performance in the country's construction industry, Zuofa & Ochieng (2015) recommended the adoption of lean strategies. This study heeds to this call by adopting lean strategies, specifically the 5S, Visual Management and the A3/PDCA Problem solving framework, as a lens to provide solution to the issue of workplace safety in the Nigerian Construction Industry. Furthermore, it has been argued that traditional effort in dealing with workplace safety is insufficient (Carayon et al. (2015). It was therefore recommended that focus should be placed on the broader sociotechnical aspect of the environment surrounding the workers. In this study, the sociotechnical systems theory was therefore adopted as an umbrella cover to investigate and provide solution to the issue of workplace safety. Deriving from the literature review and analysis, the conceptual framework in Figure 1 depicts the theoretical underpinnings of the research and show the different elements related.

This research adopts the sociotechnical systems theory to provide an overarching theoretical frame. The chapter therefore starts by presenting an overview of the sociotechnical systems theory, which is the adopted umbrella theory for the research. It among others explains the rationale for adopting this theory in this research. Furthermore, the second section of the chapter investigates the state of health and safety in the Nigerian construction industry. In line with this, the chapter also presents information about some reported accidents in the Nigerian construction industry. This is to present a clear picture of why it was necessary to conduct this research. Then the section concludes with the root causes of construction accidents based on previous studies paving way for the introduction of lean construction.

The next section of the chapter investigates lean construction. It starts with an overview of the lean thinking concept and how lean was introduced to construction management. The section then investigates various lean construction tools, including the barriers to the successful implementation of lean. The section ends with a deep investigation into the three lean construction tools to be used in creating the lean health and safety model for this thesis. Paving way for a qualitative research methodology to find what the root causes of accidents are in the Nigerian construction industry with a view to mitigating some of these root causes with a lean safety framework.

# Sociotechnical Systems Theory

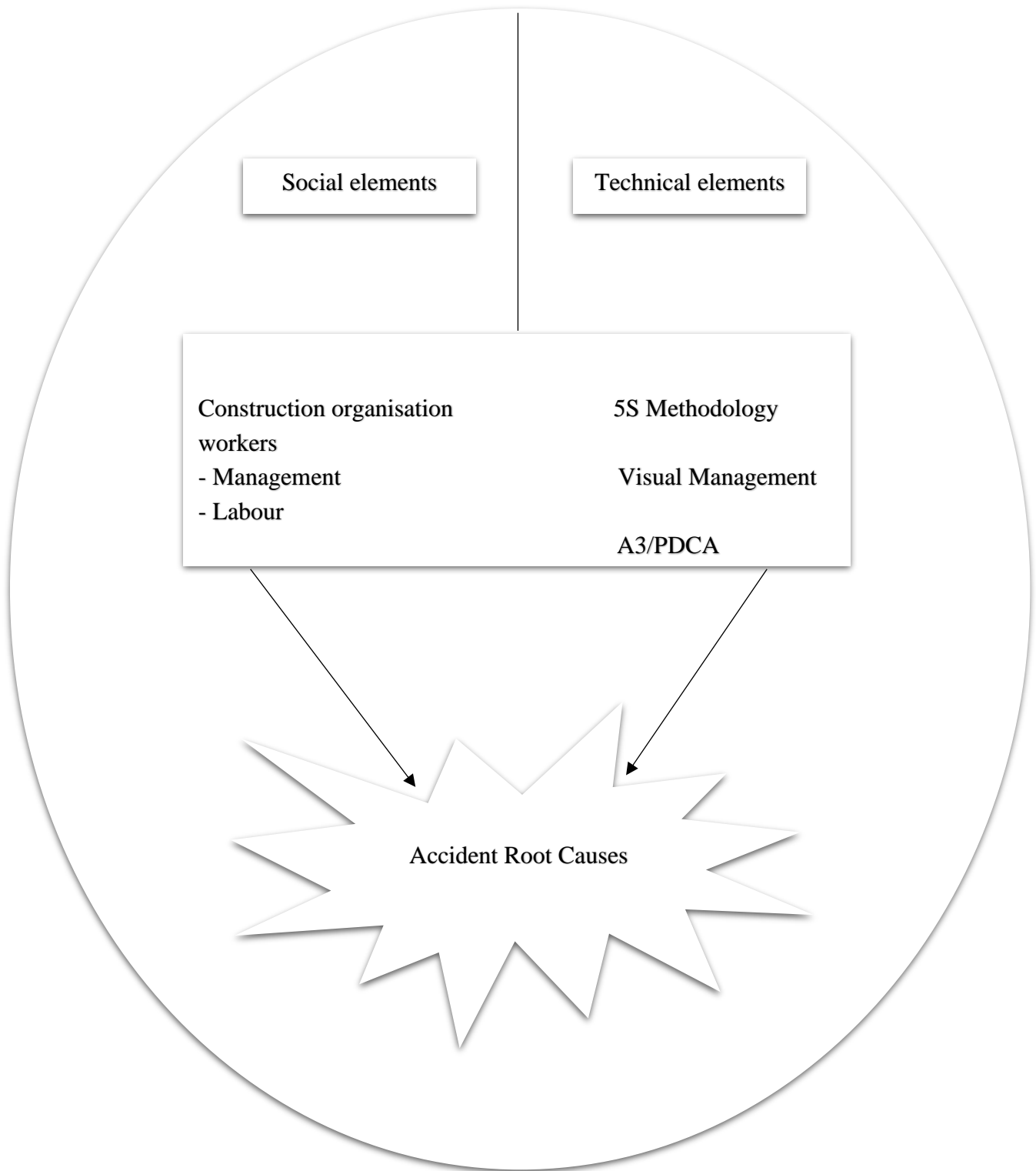


Figure 1 Research conceptual framework.

## **2.1. Sociotechnical Systems Theory**

Socio-technical theory was developed at the Tavistock Institute of Human Relations in London by E. L. Trist and his associates in the early 1950's due to production problems in long-wall coal mining (Koontz, 1980, p. 178). Trist and his associates discovered that it was not enough to just analyse social problems. Instead through dealing with problems arising from mining productivity, they discovered that the technical systems, which are "machines and methods" had a strong influence on the social systems (Trist & Bamfort, 1951). What this means is that the personal attitudes of individuals and group behaviour are influenced strongly by the technical system people work in. Based on this, the socio-technical systems theorists therefore believe that social and technical systems must be both taken into consideration and that one major task a manager has is to make these two systems work together in harmony (Koontz, 1980, p. 178, 179). The two sides must work together to achieve better and optimal performance. Even for consultants, the integration of organisational developments and technical systems in forms of technology into a total system is a task that is very hard to execute. The demand of this challenge requires that organisational development consultants must possess expertise as well as judgement in social, technological and systems theory and practice (Appelbaum, 1997).

Within various industries and their process of work operations, like manufacturing, computing, engineering, data transmission, computer assisted designs, health care, construction, safety, sophisticated information system, there has been massive technological changes. Many times, problems arise with introduction of these technological changes in organisations, some of these would include problems with implementation due to resistance by workforce, which can subsequently lead to failure by the organisation to achieve its expected target. These changes in one way or the other affect organisations substantially, especially if there is no proper integration of the social parts of the organisations to the use and techniques of these technological changes. The result to this change as Appelbaum (1997) would state is the employment of appropriate change methods and techniques that will help individuals and groups to make the best use of these available technologies. With respect to technology, organisational change in the words of Appelbaum (1997) requires a "flexible customized change model ...examined from a sociotechnical basis, which can be customized to fit the social network of the specific organisation in which technology is being introduced".

It has been stated that change programmes within organisations often fail due to the reason that their focus is majorly concentrated on one aspect of the system, in this case the technological system (LBS, 2018). In focusing more on the technological aspect, organisations fail to analyse and understand the intricate interdependencies that exist (LBS, 2018). For improvements to occur in these kinds of organisations, there is a need to involve the input of all stakeholders. Stakeholders here will include all employees that work with and make use of the system. Also, changes must be built in the work life relationship between the social parts of the organisation such that within themselves a good quality working relationship exist. Then next step is to build a relationship between this social part and the technologies that are introduced (technical systems) through proper and continuous trainings of all personnel's that will make use of the technological system. Incentive programs and awards must be introduced. These will help build a strong organisational culture where everyone within the organisations work smoothly with the systems in place. Furthermore, the concept of socio-technical theory must be properly applied and implemented. The outcome of applying the socio-technical theory according to Baxter & Sommerville (2011) leads to better ways of understanding how human, social, and organisational factors affect the ways that work is carried out and how technical systems are made use of.

### **2.1.1. Defining Sociotechnical Systems Theory**

Sociotechnical systems theory was defined by Fox (1995) as an approach that is devoted to the effective blending of both the technical and social systems of an organisation. Further expanding this definition, Carayon et al. (2015) broke down the social and technical systems as the humans, machines, work activities, organisational structures and processes that make up a given enterprise. As the name suggests, the socio-technical systems theory consist of the relationship between two very important sub-systems within an organisational system - a social part and a technical part, which can be considered as human systems and non-human systems (Mumford, 2006). The theory stipulates that for optimal performance, both parts; social (human systems) plus technical (non-human systems) must be jointly optimized to work together (Mumford, 2006). The social part of the system consists of the people within the organisational system and the relationship that exist between them. In this case grouping of individuals into teams, including the needs for coordination, controls, and boundary management. On the other hand, the technical part consists of the tools, techniques, equipment, and their associated work



structure (Mumford, 2006). Based on the above, it is argued here that socio-technical systems comprise of the entire system and not just one of two systems that lay side by side. Therefore, in jointly optimising the human systems and the non-human systems, both systems must be given equal consideration.

The objective of socio-technical system theory is the joint optimization of both sub-systems (social and technical). To this end, when technical systems are introduced in organisations, human needs must not be left aside. Both sub-systems must whenever possible be given equal attention (Mumford 2006). To put the connection of the interaction between these two parts into perspective, a pilot, and a plane illustration by Whitworth (2009) is considered. A pilot plus a plane are two side by side systems having different needs, one need being mechanical (the plane), and the other need human (the pilot). Going by the Human Computer Interaction construct, to succeed, these two systems must positively interact. The plane's controls (technical systems) must be understood by the pilots (human systems) (Whitworth, 2009). The Socio-Technical System in this case is the plane, plus its crew as a single system comprising human and mechanical levels (Whitworth, 2009).

Importantly, this theory provides a way through which people can understand the complex ways by which individuals who work collectively, cooperate, and make use of tools and technology in getting their work done successfully. In the longwall British coal mines, success was derived as Trist and his team discovered, when a new shortwall system was proposed. In the system, mining was accomplished by making multi-skilled miners work closely together as teams as opposed to the more traditional longwall method where a miner performs a single or limited number of activities. Through the introduction of the shortwall method, differences were discovered in several areas of the mine's operations. The teams became interdependent, safety improved through this, productivity increased, workers morale bolstered, and the method also took care of many of the psychological problems brought about by the longwall method. In the longwall mining, the technology that was made use of created isolation between workers on the same shift and on other shifts and this brought about a lot of problems and variances (Pasmore, 1995).

Some principles lead to the success of the shortwall method. These are listed by Trist (1981) to include the following:

1. The work system, comprising of sets of activities making up a functioning whole, now became the basic unit of focus rather the single jobs into which it was decomposable.
2. Rather than individual jobholder, the work group became central.
3. Internal regulation of the work system by the work group was thus made possible rather than the external regulations of individuals by supervisors.
4. The underlying organisational philosophy was characterised by redundancy of functions rather than redundancy of parts leading to development of multiple skills in the individual.
5. Discretionary work roles were valued rather than prescribed work roles.
6. Individuals were treated as complementary to the machine instead of as an extension of the machine.
7. For the individual and the organization, it was variety increasing as against what it was in the long wall method where it was variety decreasing due to the bureaucratic mode of operation.

### **2.1.2. Application of Sociotechnical Systems Theory in Various Fields**

At the inception of this theory, work done by socio-technical theorists centred on production, office operations and industrial engineering. However, over the years, the socio-technical systems theory has been developed into different fields of human endeavours. Sociotechnical theory being applied in healthcare, computing, social media, information and communication technology, human factor ergonomics, lean, total quality management, information systems, construction, etc (Shaw & Ward, 2007; Carayon, 2012; Hadid & Mansouri, 2014; Sawyer & Jarrahi, 2014; Kleiner et al., 2015; Carayon et al., 2015; Hadid et al., 2016). Within these fields, organisations have made use of the theory in different areas of their operation in driving both the social and technical part of the organisation and how these two parts can work harmoniously for the benefit of the organisation. Scholars have also carried out research depicting the success of the sociotechnical systems theory.

Lean practice is being applied in this present research to explore and examine how accidents, which are health and safety issues can be mitigated by first identifying their root causes. Construction process itself is dangerous and involves the use of high-level equipment and technology for project executions, and humans must work with these daily. To protect and prevent humans from accidents, safety systems, tools and techniques are developed and made

use of for safer workflow. Lean within itself is a system for work improvement and safety with a focus on waste elimination using various tools (Howell et al., 2002; Bamford et al., 2015; Bajjou et al., 2017; Dehdasht et al., 2018). Therefore, it can be argued that the construction work environment is a sociotechnical work environment and lean itself is a sociotechnical system (Shaw & Ward, 2007). It is evident in the literature that this theoretical framework has provided a fertile ground to understand health and safety issues (Longeni et al., 2013; Carayon et al., 2015), although, there are identifiable gaps in this area of research, which are outlined below.

Workplace safety has been investigated using traditional methods. However, research has shown insufficiencies in how these methods handled the issue of workplace safety (Carayon et al., 2015). It is reported that the results of safety are not always improved by these methods for some reasons. The reasons are that the methods are centred on obtaining short-term results, and it on many occasions has no integration with other functions of the organisations thereby making it isolated (Herrero et al., 2002). These insufficiencies were noted to happen because the traditional efforts tended not to take into consideration, the sociotechnical environment surrounding workers (Carayon et al., 2015). The sociotechnical systems standpoint provides intriguing and valuable understandings into the problems associated with workplace safety that traditional approach into workplace safety may not address adequately (Robertson et al., 2015). Therefore, to take care such insufficiencies, Carayon et al. (2015) developed a sociotechnical model of workplace safety from investigating literatures on sociotechnical systems, complex systems, and safety. This model is built on work system, socio-organisational context, and external environment, and has been stated as a model that can help in bridging the gap between science and workplace safety (Robertson et al., 2015). Taking cognisance of the fact that no system is permanently safe or unsafe, the sociotechnical standpoint was taken further by Kleiner et al. (2015) in their investigation of the sociotechnical attributes of safe and unsafe work systems. To achieve this, they approached the investigation from three sociotechnical perspectives: human system investigation, macro-ergonomics, and safety climate. The intent of these authors is very clear; to examine the sociotechnical system properties that can help organisations and scholars distinguish safe systems from unsafe systems. The works of Carayon et al. (2015) and Kleiner et al. (2015) both call for focus to be placed on a broader sociotechnical context of work, in this case the social, organisational, and technical work environment.

In the present study, lean being an integrated sociotechnical system (Anvari et al., 2011) will be made use of to place focus on the social, organisational and technical aspect of the work environment through implementation of its tools in construction sites for accident prevention. It is argued that lean strategies and tools can be adopted in the Nigerian construction industry to play active roles towards enhancing health and safety performance (Zuofa & Ochieng, 2015). This argument is based on the success stories of the application of some lean construction tools in construction project in previous studies (Salem et al., 2005; Tezel et al., 2011; Leino et al., 2014). Furthermore, results from a study investigating the impact of lean on operational and health and safety performance showed that through the adoption of lean practices, there was a positive impact on health and safety performance (Longoni et al., 2013). However, this study still had some low point with its results showing some differences regarding individual practices connected to lean. For example, in the samples studied, the plants with the worst operational and health and safety performance included only those that made use of the 'just-in-time' practice without human resource and prevention practice. According to authors, the results bring to light the need for both the technical and social components of lean to be present for lean to have a positive operational and health and safety impact (Longoni et al., 2013). This position is further strengthened by the study by Dadhikar & Ahlstrom (2013) where authors found the existence of a relationship between elements of sociotechnical systems theory and lean production. They posited that better plant performance is achieved when elements of sociotechnical systems theory and lean production models are implemented together as against implementing one in isolation of the other. Consequently, Hadid et al. (2016) in their study revealed that both the social bundles of lean and the technical bundles had independent positive effect on firm operation and financial performance, and operation performance, respectively. They suggested that a systematic approach should be followed by managers when implementing lean service practice and that one side of the system should not be focused on at the expense of the other. With respect to discussing safety from a sociotechnical systems perspective, it has been stated by Kleiner et al. (2015) that a key attribute to having a safer organisation is the extent to which the organisation jointly makes the best use of the social/organisational and technical aspects of workplace safety. This research takes this point into consideration. Therefore, for this study, lean tools such as the 5S, Visual Management, and the A3/PDCA problem solving framework are considered as the technical systems while the people that will make use of these tools including the organisations themselves are the social system.

Borrowing from the definition by Mumford (2006) of the social side of the organisation as consisting of people within the organisational system and the relationship that exist between them, and the technical side as consisting of the tools, techniques, equipment and their associated work structure. This study adopts the social technical system theory as the theoretical ground to harmonize both the social and technical sides so that health and safety performance can be greatly improved in the Nigerian construction using lean lens. The theory stipulates that for optimal performance, both parts; social (human systems) plus technical (machines, tools, and systems) must be jointly optimized to work together. One side must not be concentrated on at the detriment of the other.

## **2.2. Nigeria (Profile, Society, Economic Overview)**

Nigeria, well known as the Federal Republic of Nigeria is a country with a diverse geography located on the western coast of Africa with climates ranging from arid to humid equatorial (Ade-Ajayi et al., 2016). The most diverse feature of this country are its people, Nigeria is made up of several ethnic groups, over 250, and within these ethnic groups the country has about 371 tribes with their own culture, and traditions, and different languages being spoken which also include English being the official language. There are three major tribes in the country, Hausa, Yoruba, and Igbo (Akinlolu et al., 2015). The country is blessed with a large deposit of natural resources, specifically petroleum and natural gas (Ade Ajayi et, al 2016). Going by the 2016 report derived from (Trading Economics 2018) Nigeria has a land area of 910,770 sq. Km. In terms of surrounding countries, Nigeria is bordered to the north by Niger, to the east by Chad and Cameroun, to the south by the Gulf of Guinea of the Atlantic Ocean, and to the west by Benin. Aside from being large in area, Nigeria is also the most populous country in Africa (Ade Ajayi et, al 2016).

Nigeria population presently stands at 205,128,913 and is equivalent to 2.64% of the total population of the world and ranks 7<sup>th</sup> in the list of countries with highest population in the world (Worldometers, 2020). The country Nigeria has 36 States, with a Federal Capital Territory. The present capital of Nigeria is Abuja, initially, the capital was Lagos State, but Lagos State remains the number one most commercial hub and industrial city in Nigeria with a population of over 20 million people (Nwachukwu, 2016, Ade Ajayi et, al 2016). The land

terrain in Nigeria is made up of lowlands in the south, in the southeast; mountain, in the central; hills and plateaux, and in the north; plains. The principal river is the River Niger.

Economically, Nigeria is regarded as one of the largest economies in Africa alongside South Africa and Angola (Global Economic Prospects, 2018). The economy depends majorly on the oil-sectors; however, the current President of the country is doing his best to diversify the economy through development of its non-oil sectors. In line with this, recent report by Okpi (2018) suggest that the economy is presently diversifying, but oil still provides 90% of our foreign exchange. The table (1) below extracted from the report by National Bureau of Statistics (2020) shows Nigeria’s GDP composition by sector for the year 2019. This table represents estimates by the National Bureau of Statistics and shows the contribution of various sectors to the country’s GDP for 2019.

*Table 1 Nigeria's GDP Composition by Sector (National Bureau of Statistics, 2020)*

<b>Sector</b>	<b>Contributions</b>
Agriculture	25.16%
Trade	16.01%
Information & Communication	13.04%
Manufacturing	9.06%
Oil	8.78%
Mining & Quarrying	7.48%
Real Estate Services	6.21%
Construction	3.72%
Professional, Scientific, & Technical Services	3.57%
Finance & Insurance	3.01%
Education	2.13%
Public Administration	2.06%
Transportation and storage	1.48

The construction industry by this report contributes 3.72% to the country’s GDP. It has been suggested by Giang & Sui Pheng (2011) that the ability of the construction industry to stimulate economic growth also comes from the strong linkages between construction and other sectors in the economy. Therefore, the importance of the construction industry to a Nigeria’s economic

growth cannot be over emphasized as it has a positive or negative effect with the activities of every other sectors.

## **2.3. Assessing Global Health and Safety Practices in the Construction Industry**

Across the globe, the construction industry faces health and safety issues year in and year out. However, the impact of these issues on the construction industry is largely based on how individual countries lay importance to these issues and what regulations and initiatives are put in place to address these issues by Government and organisations across. The level of risk involved in construction makes it a difficult industry to work in.

In developed economies like the United Kingdom and other parts of Europe, United States, Australia, Canada, etc, and developing countries like Nigeria, South Africa, Zimbabwe, Ghana, etc, there are regulations, initiatives and practices in place to protect the health and safety of the construction workers. However, unlike in the developed economies, the developing economies are still struggling in the areas of taking the health and safety of their citizens serious which is observed by studies that have shown that health and safety is not given a priority in the developing economies (Kamunoma-Dada, 2014; Stewart 2015; Agbede et al., 2016). Regulations are hardly complied to in developing countries thereby spiking an increase in health and safety related issues (Idoro, 2008; Udo et al., 2016). This is not to say it is so perfect in the developed world. Accidents still happen on frequent basis but their structure and seriousness towards health and safety has contributed towards a reduction in accident rates in these construction industries. A look at the health and safety laws in relation to construction from both the developed and developing countries will be important at this point to portray the practice in different countries.

### **2.3.1. Construction Health and Safety Regulations and Practice in some Developed and Developing Countries**

In Britain, the basis of health and safety is the Health and Safety at Work etc Act 1974. This Act represents the primary most important piece of legislation covering occupational health and safety in the United Kingdom. It sets out in principle, the objectives that will be achieved

for making sure of high standards of health and safety in the workplace. General responsibility for the enforcement of Health and Safety lies with the Health and Safety Commission (HSC) but the actual enforcement is carried out by the Health and Safety Executives (HSE) (Health and Safety Executive n.d; Ridley, 2004). Under the Health and Safety at Work Etc Act, 1974, other important pieces of legislation that can specifically be applied in relation to construction have been formed. Some of them include: The construction (Design & Management) Regulations, The Construction (Head Protection) Regulations, The Personal Protective Equipment Regulations, The Reporting of Injuries, Diseases and Dangerous Occurrence Regulations (RIDDOR), The Working at Height Regulations, Lifting Operations and Lifting Equipment Regulations, The Management of Health and Safety at Work Regulations, The Health and Safety Signs and Signal Regulations, The Control of Substances Hazardous to Health Regulations (COSHH), and many more (Emma, 2018; HSE, 2019).

The impact these regulations have on construction is huge. A look at some of these regulations highlights their importance to health and safety practice in construction in the UK. The legal requirements for construction firms to produce risk assessment was made possible by the Management of Health and Safety at Work Regulations. The Construction (Design and Management) Regulations (2015) is what made it compulsory that there must inductions on every new project. COSHH assessment is needed because of the existence of the Control of Substance Hazardous to Health Regulations (Emma, 2018; HSE, 2019:2020).

Safe Work Australia in 2011 developed a single set of WHS laws known as model laws which is implemented across Australia. The model WHS laws comprise of the model WHS Act, the model WHS Regulations, and the model Codes of Practice (Safe Work Australia, 2017). These are supported by the National Compliance and Enforcement Policy which according to Safe Work Australia (2017) sets out principles of how WHS regulators monitor and enforce compliance with their Jurisdictions WHS laws. The main objective of the WHS Act is to provide a balanced and nationally consistent framework to secure health and safety of workers and workplaces. The model WHS Regulation sets out detailed requirements to support the duties in the model WHS Act. Aside this, they also prescribe procedural or administrative requirements to support the model WHS Act. An example is requiring licences for specific activities and record keeping (Safe Work Australia, 2017). The model Codes of Practice represent the practical guides to achieving the standards of health and safety required under the model WHS Act and Regulations (Safe Work Australia, 2017). So far so good, these laws are



being followed and obeyed by organisations, and those that fail to obey the regulations are prosecuted. Report suggests that implementation and use of work health and safety practices and compliance activities within the Australian construction industry has always been high (Safe Work Australia, 2015).

In Europe, the Health and Safety at Work etc Act 1974 provides a critical interface with the law of the European Union. There are more than 217 million workers in the EU and to protect them better from accidents and diseases, a Strategic Framework on Health and Safety at Work 2014-2020 has been adopted by the European commission. This framework identifies key challenges and strategic objectives for health and safety at work, as well as presenting key actions and identifies instruments to address these key actions (European Commission 2014; European Commission, 2017). There is also the European Union Information Agency for Occupational Safety and Health EU-OSHA, a body that works to make European workplace safer, healthier, and more productive. Along with this, this body also promotes a culture of risk prevention to improve working conditions in Europe. Health and safety executive (HSE) work with EU-OSHA and other EU Member States to facilitate sharing of good practice in Occupational Safety and Health and to promote the agency's European Campaigns (HSE, 2017). The roles played by these bodies are part of the reason for the improved health and safety within different industries including the construction industries in member States.

In developing countries, while there are regulations guiding construction practice, the outcomes from implementations of these regulations are poor (Kamunoma-Dada, 2014). In Botswana, occupational health and safety is regulated by various pieces of legislations. The main laws are the Factories Act, the Mines, Quarries Works and Machinery Act, the Agrochemicals Act, the radiation Protection Act, the Factories (Application to Building Operations and Works of Engineering Construction) including the Workers Compensation Act. According to ILO (2013), these are the various laws that provides for the safety, health and welfare of persons employed in factories and other places, including the safety and inspection of certain plants and machineries (Factories Act) in Botswana. There are also several other provisions affecting the safety, health and welfare of workers that are contained in the employment Act. While these Acts and regulations are present in the country, reports (Ooteghem, 2006; Musonda, & Smallwood, 2008; Kamunoma-Dada, 2014) suggest that the level of health and safety awareness is low, implementation of legislations is zero, there are absence of health and safety

management systems and occupational health and safety management systems is not widely practiced in Botswana.

In South Africa, although there are several health and safety regulations. E.g. construction health and safety accord. However, the leading occupational safety and health regulation is (OHSA) Occupational Health and Safety Act (ILO, 2013). Its primary aims include to provide for the health and safety of persons at work and for the health and safety of persons in connection with the use of plant and machinery, the protection of persons other than persons at work against hazards to health and safety arising out of, or in connection with activities of persons at work, establish an advisory council for occupational health and safety, provide for matters connected therewith. While legislations exist in this country, like in many developing countries, health and safety remains poor. According to Dr Terry Berelowitz, the Medical Director of OCSA, even leaders in Occupational Care in South Africa believes legislation is often ignored (OCSA, 2017). Other reports also suggest that there exists a lack of guidance in the laws and statutes regarding dealing with employee health and wellness, and compliance to Occupational Health and Safety is low (Sieberhagen et al., 2009; Stewart 2015).

## **2.4. The Nigerian Construction Industry**

As it is with other industries of its like around the globe, the Nigerian construction industry is a big employer of labour with a big proportion of its working population employed in the industry. The industry is also a big contributor to the economy of the country in terms of its contribution to the country's GDP. The contribution to GDP has experienced increase and decrease from construction in the past but from recent results the industries contribution has been increasing. According to Trading Economics (2017), Nigeria's GDP from construction averaged 559190.55 NGN Million from 2010 to 2017. A growth rate of 3.23%. Furthermore, in the fourth quarter of 2019, the GDP from construction increased to 671110.60 NGN Million from 557147.53 NGN Million in the third quarter (Trading Economics, 2020). This growth in GDP and the amount construction generates and contributes shows the economic importance of this sector to the growth of Nigeria.

As earlier positioned by Giang & Sui Pheng (2011), the ability of the construction industry to stimulate economic growth also comes from the strong linkages between construction and other

sectors in the economy. For example, other sectors would not be able to function without structural infrastructures like warehouses to store goods and services, buildings for offices, classrooms, libraries, and good roads and rails for transportation, seaports, airports, etc. In fact, previous studies (Strassmann, 1970; Turin, 1978; Wells, 1985) discussed the contribution of construction to the economy, suggesting that the contribution of construction in the economy has also been measured as a share of total employment, with Turin (1978) cited by Giang & Sui Pheng (2011) further stating that since employment in construction correlated positively with economic growth, there is a potential use of construction to generate sustained employment. In this way, the construction industry through employment of labour also contributes towards economic growth and this forms part of the industry's contribution towards the economic growth of Nigeria. The correlation between strong economic growth and the construction industry has also been established by Oluwakiyesi (2011) using United Arab Emirate (UAE)'s oil fuelled growth, China's industrial/export driven growth, and the resultant construction boom in these economies as pointers. With having healthy revenues from strong oil prices and increasing investors interest in the bridging of infrastructural deficits, Nigeria according to Oluwakiyisi (2011), has innate potential to record higher growth.

However, with respect to the developmental growth this sector can bring, there also lies some unhealthy health and safety problems that is affecting the Nigerian construction worker which can act as a downfall to this growth. A lot of contractors in the construction industry according to Oladiran et al. (2008) are much more concerned about cost, time, and quality of project delivery but are less concerned about the health and safety of the workers who are the facilitators of the project delivery to cost, time, and quality. Furthermore, the institutional and regulatory framework for construction health and safety is highly fragmented and poorly implemented (Okolie & Okoye, 2012). Daily people are killed, injured, and many suffer ill health due to construction activities. This is a major problem in the Nigerian construction industry and thus must be investigated with a means of providing possible solutions to some of these problems.

In Nigeria, Idoro (2010) construction firms operate majorly in two categories: the multinational construction firms and the indigenous construction firms (Ogbu, 2011). Kadiri et al., (2014) stated same but broke down indigenous firms into; large-scale/medium scale indigenous construction firms and small-scale indigenous construction firms. However, the industry is basically more dominated by the indigenous local firms, small and medium scale all majorly

involving in private residential projects (Ahiakwo, 2014). These firms are further divided into two major groups by Dantata (2008): the organised, “formal”, and the unorganised, “informal” sectors of the industry. The unorganised sector according to Dantata (2008) is made up mainly of simple residential buildings and structures of similar nature built by private citizens and constructed by hiring of group of artisans and labour and sometimes supervised by the owners directly, with government having no significant influence on their operation. The organised sector of the industry according to Dantata (2018), comprises of all the major companies that are legally registered to undertake organised construction projects in the country and they do this with the employment of both highly skilled expatriates and labour. In this sector, regulations and laws are adhered to, government is aware of their operations and taxes are frequently collected from them by the government.

For this research, the companies will be classed into two groups, local indigenous firms, and multinational firms. The local indigenous firms will be further broken into small-scale indigenous firms, and medium-scale indigenous firms.

## **2.5. The State of Health and Safety in the Nigerian Construction Industry**

As Okeola (2009) cited by Dodo (2014) put it, health and safety in construction is all about preventing people from being killed, injured, or becoming ill at work through appropriate precaution and providing a satisfactory working environment. The Nigerian construction industry as with others around the globe is a big employer of labour. Therefore, many of the working population are employed within the industry. As have been noted by various studies (Edwards & Nicholas, 2002; Mehta & Theodore, 2006; Health and Safety Executive, 2002; Olutuase, 2014; Udo et al., 2016), the construction industry is arguably the most hazardous industry with consistent poor accident records. In developing countries like Nigeria, the situation is even worse compared to the developed world (Idoro, 2004, 2007; 2008; Udo et al., 2016). This is due to the following reasons; lack of concern, lack of appropriate consideration for health and safety management measures or practice, lack of accurate records, and lack of statutory regulations on health and safety in construction project delivery (Idoro, 2004; 2007; 2008; Belel & Mahmud, 2012). This position is further strengthened by (Olutuase, 2014) stating that “in many developing countries like Nigeria, injury and accident rates are considerably much higher than in Europe, United States and Australia because there are no

regulations that serves to guide its operations”. Where regulations exist, compliance is almost zero as clients, consultants, and contractors give no attention to occupational health and safety.

That said, a great number of the workers in the Nigerian construction industry are exposed to various levels of risks daily as they carry out their jobs on site, which affects their health and safety. By nature, construction jobs are done in the open where issues ranging from bad weather, rain and others can cause and lead to great safety concerns on site, and with rapid project execution being a norm with construction today, the use of heavy machineries and processes all but make this industry more hazardous and riskier for the construction worker to work in. With these in mind, it is important that when a worker leaves his house in the morning for work, organisations take all necessary steps in terms of safety to ensure that workers return home to their families safely. Unfortunately, this cannot be guaranteed in Nigeria. Reason being that health and safety is not given a priority in the country, and health and safety management is poor (Agbede et al., 2016).

Construction workers have families and friends that care about them, many have wives and kids and other related families around that rely on them for the essentials of life like food, homes, education, health care and lots more. Family members do not deserve to be called that their fathers, husbands, uncles, friends, have had accident on site and sustained very fatal injuries or that they have died. The emotional trauma from that cannot be qualified. The health and safety of these workers need great consideration by both the government and organisations. Workers must be insured, Personal Protective Equipment’s (PPE’s) must be provided, workers must be given safety trainings, management must be committed to health and safety in their organisations, and safety models that seek to prevent accidents from happening must be set up and committed to because as stated by Dodo (2014), a worker will perform his or her duties to the fullest only when he or she is sure that in the event of an accident he or she will be well taken care of.

The increasing awareness of safety according to Stewart (1990) is a complex task requiring the participation of all levels in a company, which also includes the company rank and file. Accordingly, priority number one for management should be to make sure that every employee is aware of the importance of their own contribution to their own health and safety. Stewart (1990) stated some ways to achieve this to include using near miss reporting schemes, well planned safety meetings must be held regularly, including high profile safety campaigns. Priority number two is for management to show workers that they are committed to safety. To

achieve this management must promptly investigate all accidents, minor or major. Then, recommended improvements must be put in place as quick as possible and all results should be publicised widely. Finally, Stewart suggest that management should understand that accidents cost money, both because of absence at work due to sickness, and compensation paid to injured parties. Therefore, the amount spent on safety programs must be seen as the means of protecting the most important asset of companies, which are the workforce and not as pure expense. As Mullen (2004) would state, management actions will directly affect an individual's perceived safety climate in that if management is committed to safety, then it is more likely that the workers will exhibit commitment to safety.

In developed countries like the United States and the UK to mention but a few, all of these happens, and there are health and safety regulations put in place by government. Organizations work with and obey these regulations. Organisations have their own health and safety management programs put in place to reduce workplace injuries. All of these are helping reduce illnesses, accidents, and death in workplaces within these countries. One of the major keys to the success of this, is the seriousness of government and seriousness of the regulatory bodies towards enforcement of laws towards taking care of the health and safety of its citizens.

Although section 17 subsection 3c of the Constitution of the Federal Republic of Nigeria (1999) specifically made mention that “the State shall direct its policy towards ensuring that the health, safety, and welfare of all persons in employment are safeguarded and not endangered or abused”, the reverse seems to be the case. Health and Safety is not given enough consideration, especially with respect to the construction industry. The poor level of health and safety performance in the country remains, high especially with indigenous construction companies, which are many in the country. Previous studies (Diugwu et al., 2012; Idoro, 2011; Zuofa & Ochieng, 2015; Orji et al., 2016; Udo et al., 2016) have talked about lack of legislation governing occupational safety and health in the country resulting in accidents happening and not being reported and statistics not being available. Aniekwu (2007) posited that “almost all the legal requirement for safety in the construction industry was received from the English legal system with little or no modifications”. Some of these regulations is posited by Idoro (2011) as the Factories Act of 1990, which is an adaptation of the UK Factories Act of 1961. The Control of Substances Hazardous to Health Regulations of 1988 and the Personal Protective Equipment at Work Regulation of 1992, are all UK regulations and the Occupational Safety and Health Act of 1970 originally is an American regulation. These regulations have no effect

and are impracticable in the Nigerian context. The only health and safety regulation enacted in Nigeria by the legislative arm of the Nigerian government remains the Factories Act of 1994. Even this does not cover the construction industry and the body in charge of its enforcement “The Federal Ministry of Labour and Productivity Inspectorate Division” does not carry out its function. Due to this, many organisations do not comply with the regulations.

It is however important to note that compliance to these regulations alone cannot bring about improvements on accidents and occupational safety and health. As stated by Umeokafor et al., (2014) organizational culture and enforcement, creation of safety models Olutuase (2014) can also help improve and make occupational safety and health better. A lot of these are lacking in the Nigerian construction industry. The companies that recognise health and safety in Nigeria are the few multinational companies who according to Adeogun & Okafor (2013) run the health and safety policies imported from their parent countries in Nigeria. Majority of the indigenous companies see health and safety as a myopic issue. Employee attitude and behaviour towards safety is poor. There is lack of safety culture, and non-implementation of health and safety policies. Companies hardly have insurance plans for the workers, and compensation payment for injured workers are sometimes never paid (Adeogun & Okafor, 2013; Dodo, 2014). All these lead to the increasing number of construction accidents happening in the country today.

Statistically, there are lack of records to show accidents statistics in Nigeria because contractors do not report accidents to appropriate ministries or keep proper records on accidents (Agwu & Olele, 2014; Orji et al., 2016). However, according to Awodele & Ayoola (2005), the number of construction workers killed on site in Nigeria each year run into hundreds while many more workers are temporarily and permanently rendered incapacitated. A study by Abdullahi et al., (2015) on “Artisan working condition in the Nigerian Construction Industry: A case study of some States in Northern Nigeria” stated that 76.40 percent of artisan construction workers claim to have been involved in one form of accident or the other. In a study of 42 construction contractors in Nigeria by Idoro (2011) it was reported that the best safety record in 2006 was 5 injuries per worker and 2 accidents per 100 workers. According to a report in the Punch Newspaper, page 1, July 2005, a four-floor building, which was still under construction collapsed, killing not less than 25 people in Port-Harcourt, and this was barely 24 hours after a similar incident happened in Lagos Nigeria (Agwu & Olele, 2014; Dodo, 2014). In 2006, six workers were killed in a crane accident in a building construction project in Abuja. Investigation of the accident stated that the cause was due to lack of technical knowledge by

workers (Muktari & Chinyio, 2016). Olatunji et al. (2007) stated that the Construction Industry in Nigeria loses 5 – 7% of her workforce to construction accidents annually. This percentage would be on the high now with the introduction of newer equipment and tools for construction work around the world and in the country. These statistics shows just how dangerous and hazardous the construction industry is. Hence the need for industry professionals, government, and researchers in Nigeria to find ways of preventing accidents in the industry.

To this extent, a lot of safety research has been conducted to find ways in ameliorating this grave issue as seen in previous paragraphs. There however is a lack of research on frameworks that pose to prevent accidents from happening in Nigerian safety research (Williams et al., 2018). As highlighted in Chapter 1 of this thesis, these studies only give recommendations on what should be done without developing preventive models. This position has been supported by Williams et al. (2018) when they stated that studies on safety in building construction in Nigeria only put out recommendations on preventive measures. The reason for this has been attributed to a lack of reliable accident data in the country, which has prevented researchers from laying emphasis on development of preventive models. The argument here is that accident prevention models developed by researchers around the world has been created making use of accident reports. So, to create same in Nigeria, it was recommended that contractors should give reporting of accidents and near misses' recognition (Williams et al., 2018). This researcher argues that this is not enough excuse for researchers in the country to not create preventive accident models. In line with this argument, Okoye (2016) developed a social ecological model of safety performance improvement (SEM-SPI) framework and recommended that to improve safety performance in the Nigerian construction industry, the framework should be practically applied. This framework, which is based on the ecological systems theory only focuses on modelling the behaviour of construction workers towards behaving safely while on site. While this study is a step forward towards improving safety performance in the Nigerian construction industry, it does not cater for the tools and techniques that construction organisations can implement to eliminate accidents on site. Hence it has been stated by Williams et al. (2018) that there is no safety framework available for preventing accidents in Nigeria. There is therefore need for more research on creating accident preventive frameworks for the Nigerian construction industry. This study will cover this gap by creating a lean accident prevention framework, which incorporates the 5S, visual management and the A3/PDCA problem solving framework as lean tools that can be used for accident prevention on site. The study will also add to the body of literature on preventive safety models in the Nigerian construction industry.



To achieve the objective of creating this framework, it is pertinent to at this point discuss the root causes of these accidents.

## **2.6. Aspirations for Health and Safety in the Construction Industry**

As far as the construction industry is concerned, one of the most important considerations to be taken before the start of any project, is the health and safety of employees. This is because of the nature of construction being a very hazardous industry with a lot of accidents, injuries, and illness worldwide resulting from its operations (Brace et al., 2009; Haris & McCaffer, 2013; Nadhim et al., 2016). In consideration of this hazardous nature of the industry, the series of health and safety challenges, and the need to save lives of workers, it has become a global imperative requiring that these challenges are constantly addressed using effective prevention strategies (WHO, 2019).

In line with this, countries worldwide have laws, and legislations in place as explained in section 2.3.1, and are working very hard through enforcements and punishments of defaulters, all in a bid to ensure that companies adhere to these laws before the start of projects and during projects for the safety of employees. Furthermore, new laws are being made specifically for construction safety as the world evolve and construction activities changes. An example is the Construction and Design Management Regulation (2015) by the Health and Safety Executive whose clear desire is ensuring construction sites are a safe place to work in. Also, many construction organisations around the globe are now focusing on training of employees on health and safety while stakeholders have continued to carry out continuous research on further ways to improve health and safety within the industry. A report from Loughborough University on improving occupational risk management in SME's enumerated on the need for training on occupational health awareness by construction organisations to improve workers wellbeing in the construction industry (Jones et al., 2018). These are all channelled towards creating a safe work environment for workers.

From the above, it is very clear that the aspirations for health and safety in construction for today's professionals, government and stakeholders are clearly to try to reduce incidents, accidents, ill health, and death as much as possible from construction sites as construction evolve with constant introduction of new technologies. These aspirations can be achieved if organisations take proactive, and preventive risk management approach through application of

safety frameworks on site for accident prevention, and by following laws and regulations as set up by the government to protect workers. Consistent training of workers is needed to impact knowledge on workers. This is because being knowledgeable about safety is a key contributor to good decision making by workforce (Jones et al., 2018). By doing this, the aspiration of having a safe work environment can be consistently met.

## **2.7. Root Causes of Construction Accidents**

Accident statistics in the construction industry all over the world shows that a great number of accidents happen daily as workers go about their daily jobs on site (Pinto et al., 2011; Ahmed et al., 2018). This has brought about the classification of the construction industry as a high-risk industry across the world. Normally, when an accident happens, it is normal for people to want to know ‘what happened’. But ‘why what happened, happened’ is more difficult and challenging to answer. Hence in investigating a construction accident, two important points must be established. These are how the accident occurred and mostly why the accident occurred (Suraji et al., 2001). These are important because they point investigators towards identification of the root causes of the accidents and through identification of these root causes solutions can be provided to solve the identified causes. Hollnagel (2016) defined an accident as a short, sudden, and unexpected event or occurrence that results in an unwanted and undesirable outcome. Furthermore, author states that this short, sudden, and unexpected event must directly or indirectly be the result of a human activity rather than a natural event like an earthquake and must be short rather than slowly developing.

Some authors have explored various accidents in the construction industry to determine their underlying causes. The underlying causes are examined under different categories below based on the causes.

### **2.7.1. Unsafe Acts and Unsafe Behaviours**

In 1931, Herbert Heinrich, after studying 75,000 industrial accidents concluded that 88% of accidents are caused by unsafe acts of workers, 10% by are caused by unsafe conditions and 2% are unavoidable accidents. As a way of providing a preventive solution for accidents, he introduced a model known as the “Domino Theory”. In this model, Heinrich likened accident

sequence to a row of dominos, whereby when the first domino is tipped over, it topples the next, and the next topples each successive domino next to it. Heinrich stated that five factors in the sequence of an event lead up to accident. These factors are ancestry and social environment, fault of person, unsafe act or physical/mechanical hazard, accident, and injury. They comprise the five dominos. To interrupt this sequence and thereby stop the accident from happening and resultant effect thereof, Heinrich suggested that, taking off one of the factors would stop the accident and injury that would result from it. The key domino to be taken off from the sequence therefore will be factor number three, which is unsafe acts or physical/mechanical hazards (Encyclopaedia of Occupational Health and Safety, 2011). Heinrich focus was on the human factor also referred to as Man Failure, which he stated was the cause of most accidents. The idea behind the Domino theory gave rise to Heinrich further developing a chart of direct and approximate causes, which place management as being responsible for preventing accidents. It can be argued based on this theory that people are the main reason why accidents happen, and management have the responsibility of preventing accidents (Hosseinian, 2012).

Furthermore, previous research suggest that accidents are caused by unsafe act of workers and unsafe behaviour (Heinrich, 1931; Ridley, 1986; Garavan & O'brien, 2001; Chan et al., 2005; Khosrarivi et al., 2014). Along the line of this classifications, many of these studies revealed that a lot of these accidents are connected to more of unsafe work practice or behaviour of workers than to unsafe working conditions. Based on this belief, a qualitative research on why construction workers engage in unsafe behaviours on site in Hong Kong was conducted (Chouldhry & Fang, 2008). A total of twelve interviews were conducted with construction workers, both labour and management. Of the twelve, seven were construction workers who have been involved in one form of accident or the other on site. They were interviewed to explore the reason they engage in unsafe behaviours. It was evident from the work that the daily practice of employers was characterised by unsafe behaviours. The study identified that workers engaged in unsafe behaviour because of many reasons including lack of awareness regarding safety; exhibition of the tough guy characteristics by some workers; and attitude of co-workers. The study then suggested some factors management of companies should pay attention to for safety improvement. Some of these are that: management should be fully involved in safety management on site. This is because management support, their involvement and commitment to safety is the most basic factor to attain a satisfactory safety level. This support can be provided by implementing continuous training for employees, by providing

necessary protective equipment, by implementing safety management systems, which comprise planning, organising, and provision of safety polices, including working procedures, which are the main components of safety management. Other factors are that supervisors should pay attention to the psychological problems of workers as well as recognize the safe behaviours of worker. Also, it was advised that management should stop putting performance pressure on workers as this makes them work in unsafe ways leading to accidents. Furthermore, management are advised to provide a safe working environment for workers. This can be achieved by having a clean, tidy, and well-planned layout in the worksite thereby contributing to excellent safety performance. Above all, there should always be safety trainings and orientation for workers as this will provide workers the required skills to safely perform their work.

### **2.7.2. Human Error (Ferrel Human Factor Theory)**

As a further way of identifying the underlying causes of accidents, Dr Russel Ferrel created the human factor theory in 1997. Ferrel saw human error as being responsible for accident and stated that three factors lead up to human error. The factors are overload, inappropriate response, and inappropriate activities. Overload refers to a situation whereby a person is burdened with tasks that are excessive. In this case, while performing his or her job, the employee also must deal with or handle excessive noise, instructions that are unclear, stress and personal problems. Inappropriate response involves a situation where an employee detects a hazardous condition but does not correct it or does anything about correcting it. Another way for this to occur is when an employee removes a safeguard from a machine so that productivity can be improved. Inappropriate activities occur when tasks are undertaken by employees without having proper training. This results to inappropriate act by such employees. According to Ferrel, these three factors lead to human error leading to accidents (Goetsch, 2011).

### **2.7.3. Accidents caused by Unsafe Conditions and Unsafe Acts**

Having studied various accident investigation papers including accident causation theories, Abdelhamid & Evereth (2000) proposed that accidents occur due to three root causes: failing to identify an unsafe condition that existed before an activity was started or that develop after an activity was started; deciding to proceed with a work activity after the worker identifies an

existing unsafe condition; and deciding to act unsafe regardless of initial conditions of the work environment. Additionally, the accident root causes tracing model further lays emphasis on the need to determine how unsafe conditions exist before or develop after the start of an activity and who caused them to exist or develop and therefore propose that these two types of unsafe conditions happen due to one of the four causes; management actions/inactions; unsafe acts of worker or co-worker; non-human-related event(s); and an unsafe condition that is a natural part of the initial site condition. For example, there could be management failure in providing proper and adequate personal protective equipment's (PPE) for workers; there could be failure by management to safeguard or maintain tools and equipment; violating of workplace standard by management through allowing slippery floors, poor housekeeping, insufficient ventilation and many more. Sometimes management can unintentionally ask workers to carry out task that exceed human capacity or violate human factors, and industrial hygiene principles. The listed issues many times lead to overexertion injuries and illnesses. Explaining unsafe acts of workers or co-worker, Abdelhamid & Evereth (2000) stated these group may be inexperienced or new on site or may just choose to act unsafe, which apparently will lead to unsafe conditions for other workers on the site. Some examples of such unsafe acts, which lead to unsafe conditions may include but not limited to working while intoxicated or high on drugs, not obeying housekeeping rules, horseplay, operating equipment when not authorized to, removing machine safeguards etc. Some non-human related events that could lead to unsafe condition include acts of God like storms, earthquakes, flood, equipment failures, etc. Unsafe conditions that are natural part of the work environment include hidden dishes, uneven terrain, and many more. When preparation is going on in sites, these conditions are normally eliminated.

A total of 296 accidents were examined from an OSHA data between 1997 to 2001. These accidents were examined based on types and two major types of accidents were identified: struck-by-object and caught-in or compressed by equipment (Arboleda & Abraham, 2004). The study identified eight root causes of construction accidents. The first root cause identified was lack of proper training. It was reported in the study that proper training was not given to employees and because of this, employees were unable to properly recognise and avoid potential hazards that were associated with the task they were performing. The second root cause identified had to do with deficiency in enforcement of safety. It was discovered that supervisors failed to enforce safety standards even when they knew that the safety methods prescribed for avoiding hazards were not being followed. The third root cause had to do with non-provision of safety equipment. It was discovered that some companies failed to provide

their workers with the necessary safety equipment to minimize hazards. The fourth root cause identified had to do with unsafe work method. It was discovered that tasks were not being done in the normal way safety demands. The fifth root cause had to do with the site condition. It was discovered that many of the sites were unsafe to work in with many inherent hazards all over. The sixth root cause had to do with workers refusing to use the safety equipment they were provided to work with. It was discovered that even though some companies provided safety equipment for workers, some employees did not use them and some that used them, did so wrongly. The seventh root cause discovered was poor attitude towards safety by workers. It was observed that even though some workers may have been trained properly, however, due to the 'tough guy' way of thinking, laziness, or the belief that the method being used would slow down the job, they work in such ways that they do not properly avoid hazards associated with the jobs. The final root cause identified had to do with workers deviating from prescribed behaviour and performing unsafe act. This may be due to absent mindedness, tiredness, fatigue, and many other factors. These same root causes were identified by Toole (2002) as the root causes of construction accidents. Author however classed these accidents into unsafe conditions and unsafe acts of workers. Five of the identified root causes were caused by unsafe conditions within the worksite and three were caused by unsafe acts of workers.

In an analysis of 100 accidents in the construction industry with a bid to identifying the root causes of these accidents by Haslam et al, (2005), it was discovered that workers action/behaviour accounted for over 70% of the investigated accidents. The underlying factor for these behaviours had to do with inadequate safety knowledge because of deficiencies with training of workers including supervisors who authors stated also had little safety knowledge. It was noted that even those employed to train workers lacked training skills themselves. Because of this, it was difficult for them to properly train workers in ways that they could understand what they were being trained for. Another underlying cause identified had to do with workers working long hours because of high workload and paid overtime. This resulted in workers being tired and fatigued, leading to reduced concentration, making poor decisions, and safety being compromised. The study also identified workplace factors like poor housekeeping, space availability and problems with the site layout to have contributed to about 49% of the investigated accidents. These led to a lot of slips, trips and fall accidents, piercing by sharp object like nails accidents, scaffolding etc. Another root cause identified had to do with provision and usage of poor equipment and materials by companies. It was discovered that personal protective equipment and equipment used for work were of poor quality resulting

in many of the accidents. The study further identified inadequacies with risk management as a root cause. It was noted that with proper risk management, majority of the accidents could have been seen before they occurred and therefore prevented.

#### **2.7.4. Management Failures**

Cheng et al. (2010) analysed records of 800 accidents in small construction firms in Taiwan using data from the Taiwan Council of Labour Affairs. First the study classed falls and tumbles as the most common types of accidents in all companies investigated. Next, the study outlined several causes of construction accidents. First on the causes list was lack of proper training for employees. The paper reported that when workers are hired by companies, they are not properly trained to acquire enough safety knowledge. It was also stated that 74% of the companies does not provide any form of trainings for their employees. The reason stated for this is that due to trying to maximize profit, they ignore safety thereby making workers work in unsafe conditions. It was also noted that majority of the workers had low level education, coupled with the lack of trainings, which lead to unsafe behaviour by workers. Therefore, based on this, the workers are unable to recognize hazards in the work environment before or during tasks, which lead to so many accidents. Furthermore, the paper also stated another cause of accident to be due to unsafe work behaviour of workers and unsafe conditions. Three reasons were given for this: failure by employers to provide personal protective equipment for employees; when protective equipment is provided, failure by workers to make use of the equipment correctly; and when workers ignore hazard warning signs in the worksite. These authors stated that these can be corrected if employers provide long term safety education and trainings for workers. Stating that it will make workers be able to perform self-inspection before, during and after task, effectively. Another accident cause identified by this study had to do with failure in implementing health and safety management, which resulted in failures by companies to implement safe working rules and regulations, failure to perform safety inspections on tasks and task locations and failure in the area of provision of trainings to workers.

An exploratory study was conducted on construction safety management in China in which project managers, safety officers, and foremen were interviewed to find out the underlying causes of accidents in the China construction industry (Cheng et al, 2004). The study identified six major root causes of construction accidents. These were broken down into three from angle

of workers, two from the angle of organisational management and one from the quality of the materials used for construction work. From the workers angle, the identified root causes were lack of attention to the use of personal protective equipment by workers; lack of or insufficient training for workers; and tiredness of workers. From the management level the identified root causes were lack of attention to safety management by contractors/project managers, and inadequate safety levels. From material level the identified root cause was poor quality of working materials and equipment.

Gibb et al. (2010) conducted an independent research in which they reviewed literature on evidence regarding the underlying causes of construction accidents. The study identified the following as root causes of construction accidents: bad workplace management and culture; attitude and behaviour of workers; worker training and competency; equipment factors; lack of health and safety regulations and legislations; inappropriate /non-complaint procedures, and environmental factors.

A summary of the major root causes of construction accidents from the above studies point out to the following identified root causes:

- Lack of knowledge and training: This was identified as leading to inappropriate activities by workers on site, not being able to recognize or avoid potential hazards associated with the task etc.
- Non-provision of safety equipment and materials: This include failure to provide personal protective equipment to workers, poor quality work tools and materials, etc.
- Workers attitude and behaviour: This include unsafe behaviours, exhibition of tough guy characteristics, unsafe acts of workers, refusing to make use of provided personal protective equipment, using personal protective equipment in the wrong way, identifying hazard and working around such hazard without first eliminating the hazards, etc.
- Deficiencies with enforcement of safety: leading to task not being done in the specified safe manner, failure to implement safe working rules and regulations, failure to perform inspections. Attributed to lack of safety management on site.
- Lack of safety management: including inadequacy with risk management, bad workplace management culture, non-compliance to safety procedures, non-provision of or ineffective safety trainings, non-provision of PPE's, etc.



- Working long hours and overtime. This can lead to work fatigue and tiredness of workers, stress and exhaustion, reduced concentration, and workers making poor decisions and safety being compromised.
- Workplace factors such as poor housekeeping, space availability, space layout, dirty and hazardous environment.

This research considers the root causes listed above as some of the root causes of construction accidents and will investigate to see if the same can be stated to reflect what the root causes are in the Nigerian Construction Industry. This will be achieved through interviews with Nigerian construction workers at labour and management levels. The aim is to use lean construction tools to create a safety system to correct some of these root causes. The next section investigates lean construction.

## **2.8. Lean Construction**

Previous studies have identified that the adoption of lean construction techniques can be of great benefit in improving health and safety performance in the Nigerian construction industry (Zuofa & Ochieng, 2015). This argument is based on the success achieved by the application of some lean tools to improve construction health and safety studies such as Salem et al. (2005), Tezel et al. (2011), Leino et al. (2014). Hence in view of the call by Zuofa & Ochieng (2015), and the success achieved by studies previously mentioned in this paragraph, this study is applying lean construction tools to create a safety system that can mitigate some of the root causes identified in the Nigerian construction industry. In this view, this section will bring to the fore, reviews of literatures surrounding lean and its introduction into construction. The section will also examine lean safety tools like the 5S, Visual Management, and the PDCA/A3 problem solving framework, which were earlier introduced in section 1.3 as lean health and safety tools to be used in creating the safety system for this thesis.

### **2.8.1. Lean Thinking Concept**

The principles of lean were developed in the late 1950's and early 1960's within the Toyota Production System (TPS) by the Toyota Motor Company in Japan under the production engineering leadership of the production genius Taiichi Ohno (Ohno, 1988; Womack, Jones,

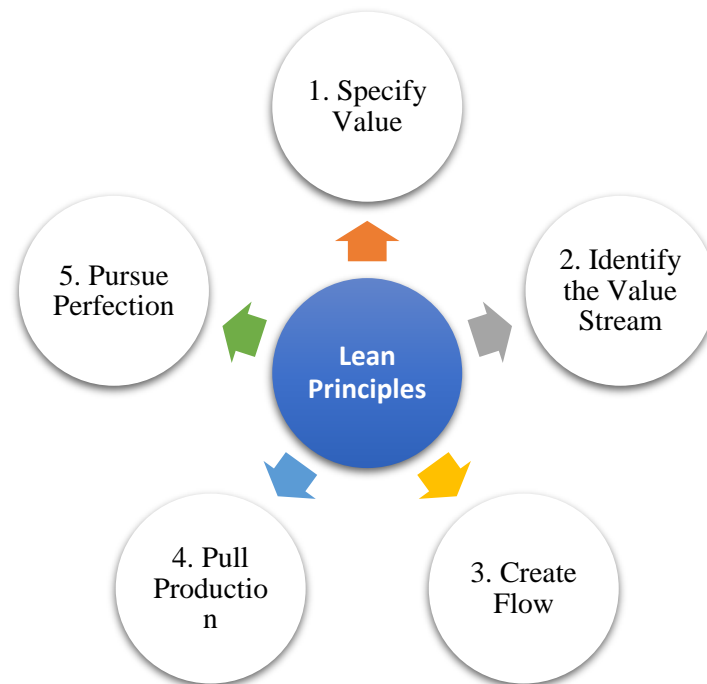
& Roos, 1990; Cullen et al, 2005). This story of lean is well captured by Womack, Jones, & Roos (1990) in their book “The Machine that Changed the World”. The first book to highlight the Japanese production methods in comparison to the traditional western mass production. This book not only highlighted the aforementioned, but also brought to light the superior performance of lean production method over mass production method, which was the method in use before the birth of lean. The key success factor in this competitive superiority and advantage was based on the application of lean production method by Toyota through the 1970s into the 80s (Womack, Jones, & Roos 1990). The Toyota Production System was based around two important factors. Melton (2005) list these factors to include (1) the desire to carry out production in a continuous flow that would not rely on long term production runs to be efficient, and (2) on the recognition that only a small fraction of the total time and effort to process a product added value to the end customer. A direct opposite of what was being practiced in the western world in this case mass production. To achieve these, there was a need to eliminate any human activity, which absorbs resources termed ‘muda’ (waste) but creates no value from every production process. The Toyota Production System identified overproduction, waiting, transportation, inventory, motion, over-processing, and defectives as seven categories of waste. So lean thinking came as an antidote to waste elimination. In this way, lean provides a way to specify value, line up value creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively (Womack & Jones 1996).

Several authors have defined lean thinking in their own different ways, for example, Bamford et al. (2014) defined lean as “an improvement philosophy that aims to continuously increase the efficiency and effectiveness of a system through driving out waste”. Thatcher (2010) defined lean as “the relentless pursuit of the elimination of waste from every process with the ultimate goal of providing world class quality, delivery and services to customers at the lowest possible cost”. Furthermore, lean thinking is defined by Thatcher, (2010) as a principle driven, tool-based philosophy that focuses on eliminating waste so that all activities and steps add value from the customer’s perspective.

The basic idea behind lean is being able to determine the value of any given process through distinguishing value-added steps from non-value-added steps and eliminating waste so that at the end, every step ultimately adds value to the process. The principle behind achieving all of these, known as the principles of lean thinking, are discussed below.

## 2.8.2. The Principles of Lean Thinking

Lean thinking includes five principles. Womack & Jones (1996) list these five principles as: specify value; identify the value stream; create flow; pull production; pursue perfection. These are represented in Figure 2 below.



*Figure 2 Lean Thinking Principles (Womack & Jones, 1996)*

**Specify Value:** Value according to Womack & Jones (1996) represents the critical starting point for lean thinking and can be defined only by the ultimate customer. Value only becomes meaningful when it is stated out in terms of a specific product, example, a good or a service, and in many cases both, which meets the needs of the customer at the exact price the customer wants and at the exact time the customer needs it. Value is created by the producers of goods and services and yet value to the producer is very hard to define accurately. The reason for this is because value can only be defined by the ultimate customer based on the satisfaction of the customer on the product received.

**Identify the Value Stream:** Womack & Jones (1996) defined a value stream as “the set of all specific actions needed to bring a specific product (whether a good, a service, or, increasingly, a combination of both) through the three critical management tasks of any business: the problem-solving task, the information management task, and the physical transformation task.

The problem-solving task involves steps from concept of the product through to production launch. The information management task involves steps from order-taking through detailed scheduling to delivery. The physical transformation task involves steps from raw materials to finished product in the hands of customers (Womack & Jones, 1996). The identifying the value stream step is one, which according to Womack & Jones (1996) almost always exposes a high amount of waste also termed muda. The principle of identify the value stream involves making use of value stream mapping. Value stream mapping is according to Rother & Shook (1998) a pencil and paper tool, which helps one to see and understand how material and information flow when products makes their way through the value stream. This map not only helps you see waste, it also helps see the sources of the waste in your value stream.

**Create Flow:** After specifying value, the value stream for the product in question mapped out fully, and waste eliminated from the value stream, the next step is to make the remaining value creating step flow smoothly without interruptions or delay of any sort (Womack & Jones, 1996). Some ways to achieve this according to Doanh (2017) is by breaking down the steps, reconfiguring the production steps, levelling out the workload, training employees to be multi-skilled and adaptive, and creating cross functional departments.

**Pull Production:** Pull alongside flow principles stands as the core characteristics of lean thinking. Waste elimination depends on them (Picchi & Granja 2004). Womack & Jones (1996) explains pull as a situation where goods and services should not be produced by anyone upstream until it is asked for by the customer downstream. A situation where a product is built based on demands of the customer rather than on forecast. For a pull-based system, the goal is to limit inventory and work in process items while making sure that all necessary materials and information are available for work to flow smoothly (Doanh, 2017). This will ultimately lead to being able to deliver work just in time, optimize cost and efficiency, eliminate activities that creates waste, meet actual demand, and increase productivity and flow efficiency.

**Pursue Perfection:** With the first four stages, specify value, identify value stream, make value creating steps flow, and pull production, waste is prevented. To keep this going, and to continuously grow in perfection, there is need to pursue perfection. The pursue perfection is the most important of all the 5 principles. This is because through this, lean thinking and continuous improvement becomes a part of the culture of the organisation (Doanh, 2017). When delivering products for the needs of customers, it is important that every employee strive towards perfection.

## **2.9. Emerging Lean Thinking in Construction Context**

All over the world, the problems facing construction such as time overruns, low level of productivity, insufficient quality, continuous decline in profit margin, delay factors and over spending in project delivery, weak performance management, inferior working conditions, health and safety, etc, are, and were well known and have been discussed by several authors (Koskela, 1992; Lathan, 1994; Lim & Alum, 1995; Egan, 1998; Salem et al., 2005; Sambasivan & Soon, 2007; Aziz & Hafez, 2013) with a need for solutions to these problems. To take care of the problems facing the industry, several solutions have been preferred. Industrialization, computer integrated construction, robotized and automated construction, and several initiatives leading to the likes of the Egan report on rethinking construction, etc are some of the solutions proffered (Koskela, 1992; Koskela, Ballard, & Howell, 2003). Still, the problems persisted. There was therefore a need for a process/system that would increase efficiency, increase profit, remove delays and waste, improve safety, and give value to the clients through removing of non-value adding activities termed ‘muda’ from construction processes. A change from the traditional construction project management process to a new management process that can guarantee the listed improvements.

Meanwhile, in manufacturing, there was a system making wave, which is based on a new production philosophy known as lean production, which had originated from Japan in the 1950’s having it’s root in its application to the Toyota Production System. Simply stated, the idea behind the Toyota Production System is to increase production efficiency through consistently and thoroughly eliminating waste (Ohno, 1988, Koskela, 1992). This new production philosophy did just this in the car manufacturing and electronics industries where it had very great impact, which lead to it becoming prominent as the mainstream approach practiced by major manufacturing companies in Europe, America, and Japan. Lean production system based its foundation on the fact that in all production systems, there are two facets: one being conversion and the other being flow. In the traditional production system, the situation is different, all activities leading to the transformation of products are considered as value adding conversions. Thus, in traditional project delivery systems as Koskela (2002) would state, the ‘task’ of project delivery is pursued while value maximization and waste minimization are neglected. In lean project delivery, transformation, flow, and value are all pursued (Koskela 2000).

Overtime, the application of the new production philosophy soon spread to other fields. Koskela (1992) listed some of these fields to include services, customized production, and administrative and product development. With the success of lean production in manufacturing, Lauri Koskela in 1992 introduced lean to the construction industry through his work on “Application of the New Production Philosophy to Construction” and stated that “the new production philosophy should be adopted in construction such that actual construction should be viewed as a conversion process and, also as a flow process consisting of both waste and conversion activities”.

Lauri Koskela hosted the first conference of the International Group for Lean construction (IGLC) in Espoo, Finland in 1993 (Ballard & Howell, 2003) and it was in this conference that the name lean construction was adopted by the small group of researchers at the conference. Since then, there has been a large growth of the group with so many conferences being held every year in different locations within Europe, Asia, North America, South America, etc and the proceedings for these conferences are published and can be found in the IGLC websites. All these contribute towards the growth and development of lean construction.

Since the introduction of lean to the construction industry by Koskela (1992), several studies have been conducted (Ballard & Howell, 1998; Howell & Ballard, 1998; Huovila & Koskela, 1998; Howell, 1999; Howell & Koskela, 2000). Majorly from the International Group for Lean Construction (IGLC), which has led to formulation of theoretical foundation for lean construction, and which has significantly contributed to the success of lean construction (Salem et al., 2005). These studies and practical research have led to the implementation of lean construction practices in the construction industry of various countries across the world (both developed and developing) with success stories and great benefits (Sarhan & Fox, 2013). Some of these countries include the United Kingdom, the United State of America, Brazil, Germany, Denmark, Singapore, Korea, Australia, Ecuador, Finland, Chile, Peru, Netherlands (Ballard & Howell, 2003; Thomassen et al., 2003; Salem et al., 2005; Alarcón et al., 2006; Erikson, 2010).

### **2.9.1. Definitions of Lean Construction**

There is no generally acceptable definition for lean construction as different authors have come up with their definitions of what lean construction is based on their own understanding of the concept. However, some definitions by some authors are stated below. Bertelsen (2004)

described lean construction as an adaptation and implementation of the Japanese manufacturing principles within the construction process, which takes construction as a special kind of production, which while delivering project, maximize the value for the client and minimize the waste. Construction Excellence (2004) defined lean construction as a philosophy that is founded on the concepts of lean manufacturing and stated that lean construction is about managing and improving the construction process in order to deliver profitably, what the customer needs. Salem & Zimmer (2005) takes the definitions further by defining lean construction as the continuous process of eliminating waste, to meet or exceed all customer requirements, by focusing on the entire value stream, and pursuing perfection in the execution of a constructed project. Further, Abdelhamid & Salem (2005) defined lean construction as “a holistic facility design and delivery philosophy, which has as its overarching aim, the maximization of value to all stakeholders through systematic, synergistic and continuous improvements in the contractual arrangements, the product design, the construction process design and method selection, the supply chain, and the workflow reliability of site operations”. More recently, Aziz & Hafez (2013) defined lean construction as making use of the same principles of lean production for waste reduction, and to increase productivity and effectiveness in construction process.

Abdelhamid & Salem (2005) described lean construction projects as projects that cost less, are safer to carry out, easier to manage, completed sooner, and are of better quality. Further, Abdul Rahman, Wang, & Lim (2012) stated the three features that distinguish lean construction practice from conventional construction management. The features include that: the focus of lean construction is on waste reduction of any kind that may exist in the construction process. They include such waste as inspection, transportation, waiting, and motion waste; the aim of lean construction is the reduction of variability and irregularity such that material and information can flow in the system uninterrupted; materials to be used for construction should only be on site when needed.

Since its introduction to construction, lean has been successfully used to continuously improve and increase construction process through waste elimination. Formoso et al., (2002) defined waste in construction as the loss of any kind of resources, be it material, time, labour, equipment, and capital, produced by activities that generate direct or indirect costs but do not add value to the final product from the client’s point of view. Poon et al., (2004) defines construction waste as waste resulting from materials that are defective, materials that are extra,

as well as wastage. Abdul Rahman et al. (2012) defined waste in construction as including not only waste of material but also overproduction, waiting time, defects, inventories, movement, processing, transportation, and substitution. Howell et al. (2002) broadened this definition of waste by adding that incidents that disrupt the flow of work or lead to injury are waste. In-fact, safety has been said to have a significant impact on construction related waste. This can be seen through lost labour hour due to illness, or job-related injuries. They do not add value to the construction process (Forbes & Ahmed, 2010).

Lean has its tools and techniques, some of these tools and techniques are discussed next.

## **2.10. Lean Construction Tools**

To help with the identification and elimination of waste that add no value to construction processes, several lean tools and techniques have been created, and used successfully (Zhang & Chen 2016). Some of these lean construction tools are originally adopted lean production tools. Additionally, to bring about improvement in performance in the overall outcome of construction processes, more tools were developed with the Last Planner System of production control being the most developed (Ballard 2000; Salem et al. 2005). The effectiveness of the Last Planner system and other lean construction tools like increased visualisation, daily huddle, 5S, and error proofing have been tested by (Salem et al., 2005). Sarhan et al. (2017) in their paper gave a summary of lean tools and techniques that support lean construction implementation. The tools and techniques listed include; the Last Planner System, value stream mapping, standardized work, 5S, kaizen, total quality management, increased visualization, fail safe for quality and safety, daily huddle meetings, first run studies, five whys, just in time (JIT), plan of conditions and work environment in the construction industry, concurrent engineering, pull 'kanban' system, error proofing (poka-yoke), target value design (TVD), partnering, total productive maintenance, (TPM), computer aided design (CAD), and six sigma. (Zhang & Chen 2016) listed the following lean tools and techniques in their work; Last Planner System, concurrent engineering, daily huddle meeting, kanban system, value stream mapping, quality management tools, BIM, and human resource management.

Bajjou, Chafi, & En-Nadi, (2017) investigated the potential effectiveness of lean construction tools and listed the following tools: The Last Planner System, visual management, 5S, and error proofing. Bashir et al. (2011) reviewed the impact of lean construction tools in reducing



accidents on construction sites and looked at the Last Planner System, 5S, and error proofing (Poka Yoke). Barbosa et al. (2013) listed three lean construction tools in their work: Last Planner System, production system design, and visual management. Ansah et al. (2016) listed the following as suitable lean construction tools; Last Planner System, concurrent engineering, 5S, daily huddle meetings, first run studies, visual management, fail safe for quality, construction process analysis, Kanban (Pull System), Just-In-Time, work standardization, value stream mapping, statistical process control, work structuring, pareto analysis, Poka-Yoke (error proofing), continuous flow, six sigma, failure mode and effect analysis (FMEA), bottleneck analysis, kaizen, PDCA, 5whys, muda walk, root cause analysis, check sheet, synchronize/line balancing, jidoka/autonomation, fifo line (first in, first out), and team preparation.

A list of some of these tools from the various studies above with their functions and requirements are listed in the table below. Some of these tools will be briefly discussed before going into a deep discussion of the lean tools (5S, Visual Management, and A3/PDCA Problem Solving framework) that are to be used for this research.

*Table 2 Lean Tools (Ballard 2000; Salem et al., 2005; Ansah et al., 2016)*

<b>Tools</b>	<b>Function</b>	<b>Requirements</b>
Last Planner System	Workflow and Project Variability.	Reverse phase scheduling. Six week lookahead. Weekly work plan. Reasons for variance. PPC charts. Pull Approach. Communication and collaboration.
Visual Management	Transparency and Discipline.	Commitment Charts. Safety Signs. Mobile Signs. Project Milestones. Communication.
5S	Transparency.	Sort, set in order, shine standardize, and sustain.

Daily Huddle Meetings	Communication, continuous improvement.	Meetings of all foremen. Start of the day meetings.
Just in Time	Efficiency improvement, continuous improvement.	
Error proofing	Process Improvement.	
Fail Safe for Quality and Safety	Process variability.	Check for quality. Check for safety.
First Run Studies	Continuous Improvement	Plan, Do, Check, Act
PDCA	Problem Solving	Plan, Do, Check Act
5 Whys	Problem Solving	5whys
Value Stream Mapping	Process Improvement	
Kaizen	Continuous Improvement	
Muda Walk	Problem Solving	

Other tools include the Kanban (pull system), total quality management, six sigma, failure mode effect analysis, construction process analysis, statistics process control, work standardization, jidoka/automation, BIM, bottleneck analysis, pareto analysis, fifo line (first in, first out, work structuring, root cause analysis, production system design, continuous flow, synchronised/line balancing, check sheet, target value design, etc. The list is extensive.

### **2.10.1. Last Planner System (LPS)**

The Last Planner System according to Ballard (2000) is a “production control mechanism for transforming what ‘should’ be done into what ‘can’ be done, thus forming an inventory of ready work, from which weekly work plans (wvp) can be formed” Ballard further explained that; including assignments on the (wvp) is a commitment by the last planner of what they ‘will’ actually do. Making it a system that is centred on ‘Should, Can, Will’ analysis (Ballard, 2000). “Should” represents all the tasks in the project master plan that are required to be carried out in accordance with the schedule requirements. But because of constraints of different types, not all the tasks may be executed, therefore “can” indicates the works that can actually be completed even with the various constraints on site. “Will” looks at the work commitment that will be made with all constraints taken into consideration (Salem et al., 2005). The last planner system addresses workflow, and project variability in construction (Salem et al., 2005). The

system was designed for making work planning processes and workflow highly reliable as well as building trust within a collaborative team environment (LCI 2015). In this system, detailed plans are made by who executes work. In other words, the person or group accountable for planning of operations is the last planner. This can be the foremen, site supervisors, work bosses, etc and they decide what work can be done on site. There is a sequence of implementation in the last planner system, which through a pull technique sets up an efficient schedule planning framework, which according to Salem et al. (2005) shapes work flow, work sequence, and work rate; matches workflow and capacity; develops work execution methods; as well as communication of improvement between trades. This sequence of implementation includes master schedule, reverse phase schedules (RPS), six-week lookahead, weekly work plan (WWP), percent plan complete (PPC), constraint analysis and variance analysis.

### **2.10.2. Visual Management**

Increased visualization according to Salem et al. (2005) is a communication tool used in the workplace to communicate key information to the workforce effectively through posting of various signs and labels in various locations around the construction site. The principle behind visual management is that when people see things, they get attracted to that thing. In other words, people are usually attracted by what they see. Hence, as Salem et al. (2005) would state, elements like workflow, performance targets, and specific required targets, if visualized, can be remembered by workers. The signs can come in the form of notice boards, indication lights, visual display units, kanban, etc. The signs include signs that are related to such things as safety, schedule and quality, and the objective of visual management is to make communication simple and attractive by use of visual aids (Tezel et al., 2009).

### **2.10.3. Daily Huddle Meetings**

This is a technique used for communication and for daily meeting process of project teams for accomplishment of workers involvement. It involves situations where brief start up meetings are held on daily basis with the aim of collecting data on the state of work since the previous day's meeting. This meeting creates an environment where work progress reports are made, and where issues dealing with or affecting work progress and safety are made especially if

these issues will make it impossible for an assignment to be completed. This it achieves through a two-way communication process, which is the key to the daily huddle meeting (Salem et al., 2005).

#### **2.10.4. 5S Methodology**

It is a known fact that good housekeeping will eliminate problems associated with safety, improve workers morale, and increase efficiency and effectiveness (Becker, 2001). The 5S is known in Japan as the basic principle of industrial housekeeping. It refers to 5 Japanese words used as a guide to keep the workplace clean and safe. The 5 Japanese words that make up the 5S's are seiri (sort), seiton (set in order), seiso (shine), seiketsu (standardize), and shitsuke (sustain). The goals of the first two step in this guide are to eliminate searching for parts or tools, to avoid movements and actions that are not necessary, and prevention of the use of wrong tools or parts (Becker, 2001).

#### **2.10.5. Just in Time**

Just-in-time is a manufacturing system that was developed in Japan by Taiichi Ohno with a primary goal of continuously reducing and ultimately eliminating all forms of waste and improving quality (Brown & Mitchell, 1991; Kumar & Panneerselvam, 2007). The aim of just-in-time is the achievement of “zero concept”, meaning achievement of the goals of zero defects, zero inventories, zero queues, zero breakdown, etc. Just-in-time ensures that right parts are supplied, in right quantity, in the right place and at the right time (Kumar & Panneerselvam, 2007).

#### **2.10.6. Kanban**

Kanban according to Arbulu et al. (2003) is lean approach developed in the automotive industry to pull materials and parts through the production system on a just-in-time basis. Kanban, which is a multistage production scheduling and inventory control system is a plastic card that contains all the information needed for production/assembly of a product at each stage, including details of its path completion. The cards are used for controlling production flow and inventory. The Kanban system according to Kumar & Panneerselvam (2007) facilitates high

production volume and high capacity utilization with reduced production time and work-in-progress.

### **2.10.7. Fail Safe for Quality and Safety**

The poka-yoke device was introduced by Shingo (1986) as new element that stops parts that are defective from flowing through the process. It banks on the generation of ideas that alert for potential defects. Fail safe for quality has the same similarity to the lean manufacturing visual inspection tool (poka-yoke device) and can be extended to safety. This tool has some relationship to safety risk assessment tool from traditional manufacturing practice in that they both require actions plan that prevent bad happenings (Salem et al, 2005).

### **2.10.8. First Run Studies**

First Run Studies is a part of continuous improvement effort used for redesign of critical assignments and include productivity studies. This it does through reviewing work methods by redesigning and streamlining the different functions involved (Salem et al, 2005). To show the work process or illustrate the instruction, the first run studies commonly make use of things like video files, photos, or graphics. To develop this study, the plan, do, check, act (PDCA) cycle is made use of. Where plan refers to selection of work process to study, assembling of people, analyzation of process steps, brainstorming on how to eliminate steps, and checking for safety, quality, and productivity. Do refers to trying out ideas on the first run. Check describes and measures what happens. Act deals with reconvening the team and communicating the improved method and performance as the standard to be met by the team (Salem et al., 2005). The “first run studies” according to Salem et al. (2005) is like the combination of lean production tool, the traditional manufacturing technique; time and motion study, and graphic work instructions.

### **2.10.9. Kaizen**

Kaizen is a Gemba Kaizen term meaning continuous improvement and consist of a compound word made up of two concepts: Kai meaning ‘change’, and Zen meaning ‘for better’ (Singh &

Singh 2009). Chen et al. (2000) defines kaizen as a process of continuous, incremental improvement of the ‘standard’ way of work. It is tailored towards the everyday worker and management, with a primary aim of improving the workplace even on a small scale (Shang & Sui Pheng, 2013). For Kaizen to thrive in any organisation, it must be adopted in the culture of that organisation. According to Singh & Singh (2009), when successfully implemented, Kaizen can result in a cooperative atmosphere in which everyone is aware of the key goals and measures of success. Kaizen can be applied in any area in an organisation in need of improvements.

#### **2.10.10. Error Proofing**

According Dudek-Burlikowska & Szewieczek (2009), the word Poka-yoke originates from Japan and mean ‘resistance to errors’ (avoid (yoker) errors resulting from inattention (poka). It was introduced in 1961 by Shiego Shingo and is a method used to prevent defects and errors originating in the mistake. The idea behind poka-yoke is about designing your process such that mistakes are impossible, or easily detected and corrected. Poka-yoke devices have two basic categorisations: prevention and detection. A prevention device engineers the process to make it impossible to make a mistake at all. While a detection device alerts the user when a mistake has been made so that the problem can quickly be corrected by the user. The poka-yoke device has three basic functions according to Dudek-Burlikowska & Szewieczek (2009), to prevent or reduce defects; shutdown, control, and warning.

#### **2.10.11. Plan Do Check Act (PDCA)**

PDCA is a continuous improvement tool and represents a four-step quality model, which is the “plan-do-check-act” (PDCA). The PDCA cycle is one of the most widely used model.

- Plan means to identify an opportunity and plan for change.
- Do means to implement the change on a small scale.
- Check means to use data to analyse the result of the change and determine if it made a difference.
- Act means if the change was a success, then implement the change on a wider scale and continuously assess your result. If the change did not work, start the cycle again.

The idea behind continuous improvement is to involve the workforce to come up with many improvement ideas. To achieve this in construction safety, every member of the workforce is expected to bring up three to five improvement ideas every month in all areas of the construction process and if it is an organisation making use of the 5S as a safety improvement tool, workforce is expected to continuously improve every day on the overall 5S process. This helps enhance safety on site.

## 2.11. Barriers to implementation of Lean in Construction

For a successful implementation of lean, it is important that the barriers to its implementation experienced by those that have successfully implemented it be investigated. Failure to do this can lead to hindrances to its implementation.

Several studies have been conducted to investigate the factors that could act as hindrances to the successful implementation of lean construction in various countries (Mossman, 2009; Sahan & Fox, 2013; Shang & Pheng, 2014; Bayhan et al., 2019). These investigations have come up with different identified barriers. The barriers listed from these studies are listed in the table below with authors.

*Table 3 Lean Implementation Barriers*

<b>Lean Construction Implementation Barriers</b>	
<b>Authors</b>	<b>Listed Barriers</b>
Alarcón et al. (2005)	Lack of time for implementing new practice, lack of training, organisational element, and lack of self-criticism.
Salem et al. (2005)	Non-commitment by top management, mind-set, and behavioural change, misunderstanding of lean concept, lack of interest by clients, lack of training.
Olatunji (2008)	Not understanding the lean concept, difficulty in getting top management commitment, government bureaucracy and instability, lack of equipment and inadequate funding.

Abdullah et al. (2009)	Lack of attentiveness and commitment from top management, difficulties in understanding the concept of lean construction, lack of proper training, tendency of construction firms to apply traditional management concepts as opposed to productivity and quality management concepts.
Mossman (2009)	Lack of senior management support, lack of time, lack of resources.
Sarhan & Fox (2013)	Lack of adequate lean awareness and understanding, cultural and human attitudinal issues, lack of top management commitment, fragmentation and subcontracting, procurement and contracts, time and commercial pressure, financial issues, educational issues.
Shang & Pheng, (2014)	Lack of long-term philosophy, absence of lean culture in organisation, use of multi-layer sub-contracting, People and partner issues, managerial and organisation issues, lack of support issues, culture and philosophy issues, government issues, and procurement issues.
Wandahl, (2014)	Cultural resistance to change, lack of commitment by top management, lack of communication, lack of leadership, lack of knowledge, lack of training.
Ayalew & Dakhli, (2016)	Lack of knowledge, lack of industry support, insufficient support among project team, employee resistance, lack of standards.
Sarhan et al. (2018)	Influence of traditional practices, unfavourable organisational culture, lack of technical skills about lean techniques, lack of understanding of lean approaches, lack of top management commitment, and lack of support from the government for technological advancement.
Bayhan et al. (2019)	Financial issues, managerial issues, technical issues, workforce issues, culture issues, government issues, and communication issues.

The barriers listed in the table shows that almost the same sets of barriers were experienced in various countries by the listed authors during implementation. These barriers can be classed under six different categories; management barriers; government barriers; financial barriers, cultural barriers, educational barriers, and time barriers. Therefore, for a successful implementation of lean construction practices, these barriers must be given consideration. Top



management of various organisations implementing lean must show continuous support and commitment towards its implementation (Mossman, 2009; Sarhan & Fox, 2013). A lack of this support and commitment will see construction stakeholders facing difficulties in adopting lean construction concepts within their organisations (Mossman, 2009; Abdullah et al., 2009; Sarhan et al., 2018). Construction workers must be properly trained so that they can gain the necessary knowledge, skills and expertise to be used and applied, in the implementation of the lean construction concept in their various projects (Alarcón et al., 2005; Ayalew & Dakhli, 2016). The provision of training and education for stakeholders is very important because without this, stakeholders may misunderstand the concepts of lean, which can lead to failure in lean implementation (Salem et al., 2005); Sarhan et al., 2018). Thus, top management have a big role to play in making sure trainings and education are provided.

## **2.12. 5S Methodology as a Lean Tool**

The 5S is a house keeping methodology and is defined by Ho (1999) as a technique used in organisations to establish and maintain quality environment. It achieves this by organising the workplace in a clean, efficient, and safe manner with the use of visual cues such that human capability and productivity is enhanced. Hence it is said that the 5S constitutes the basis for a visual workplace and many visual controls (Tezel & Aziz, 2016). The name 5S represents five Japanese words seiri, seiton, seiso, seiketsu and shitsuke. In English, these words mean sort, set in order, shine, standardize, and sustain. Rahman et al. (2010) stated that applying the 5S techniques could raise considerably, the environmental performance in production line including safety and good housekeeping. This was further corroborated by Grover (2012) when he stated that safety and good housekeeping practices are the key components of the 5S philosophy. The program is usually implemented through creating small teams that work together to get work materials closer to operations. This is so that materials are right at workers' fingertips and well organized and labelled to make operations quicker with the smallest amount of wasted time and materials (Grover, 2012).

Yang, Zhang & Zhang (2004) describes the three supporting pillars of the 5S based on the one by one implementation process of the steps that makes up the process and divides this into three stanchions:

1. Creating a disciplinary process of project. 5S is a system that changes the way of how people behave. It is therefore important that each person undertaken the 5S be trained on how to be responsible.
2. Creating an environment that is clean, that is cleaning every nook and cranny, getting rid of dust and dirt so that the site can look brand new and exciting.
3. Creating a visual management project. Observe with your eyes to find out where defects are; help each and every man complete their jobs very well, to avoid mistakes. This refers to the standardizing the 5S.

An explanation of the five words that make up the 5S is important at this point to make readership understand better. However, it is also important to point out that before the implementation process of any 5S, employees must first be trained. The training helps to encourage employees to become actively involved in the application exercises and provide employees with the basic knowledge needed to embark on the 5S exercise (Kumar & Kumar, 2012). It has been established that one of the common mistake organisations make when running the 5S program is failure to provide adequate training to employees before the start of the program (Kumar & Kumar, 2012).

### **2.12.1. Seiri / Sort**

This represents the first step in the 5S process. Here, what is needed and not needed in the work area is sorted out and separated, and what is not needed are discarded (Poornima, 2011). Red tags are placed on items that are not needed for work. It requires that all items that do not belong in the working area be removed and only those that are needed for the operation in question be left. To achieve this, first the objectives for the sorting must be defined. Here question like “why are we doing this?” should be asked. Knowing the answers to this question would put us in a better position to decide how to go about the sorting. In the sorting process, the employees in the workplace identify what is not needed, and the managers and supervisors take responsibility for disposition of the not needed materials.

There are two process to follow here (Kumar & Kumar, 2012):

1. Identify the items that are not needed and use red tag on them to indicate that they should be taken off. The employees take responsibility for this.

2. Evaluation and disposition of the not-needed red tagged items that would need placing in a specified 5S holding area for evaluation. The managers take responsibility for this by making sure that space is available to be used as holding areas for the items.

Evaluation of the items in the work area should be performed by the experienced employees in the workplace and they must make sure that they take the best decision relating to the final disposition of the tagged item. By doing this, risk involved with accidentally tossing valuable items are reduced greatly. In conclusion, the emphasis of the sort process is on stratification management and dealing with causes to get rid of what is not needed and to find causes before they become problems.

### **2.12.2. Seiton / Set in order**

In this stage, items that are needed for operations are arranged such that every item has a place, and everything is in its place and are ready and easy to use such that searches are eliminated, and items can be used when needed (Poornima, 2011). It involves organizing the needed items in such a way that it best supports the workers carrying out the work and they can reach to any item they want with ease. This stage provides an even good opportunity to organize the work better focusing on neatness. Improvements are made progressively in this stage by placing items that are already nearby even closer to the point of use. Items that are regularly needed but are presently stored far away can be moved closer to the point of use, and items that are not used regularly can be kept nearby but out of the way of items that are regularly used daily. Set in order can be applied in both big and small areas. The emphasis of the set in order process are on functional management, search elimination, prevention of mistakes caused by misplaced items, time reduction, items needed are close by, avoidance of accidents due to availability of adequate space for all operations including space for movement and storing of materials (Poornima, 2011; Kumar & Kumar, 2012).

### **2.12.3. Seiso / Shine**

To maintain standards and identify defects, it is important the work area and equipment is cleaned thoroughly and on a regular basis such that everything is returned to a nearly new state. This is the stage where that is done. It means getting rid of waste, grime, and foreign bodies

and making things within the workplace clean because work areas that contains contaminations like dirt, dust, or oil will cause defects to products, malfunction to equipment and process, including safety hazards to workers.

Having clutters around the workplace is a form of contamination. These clutters build with time through by-products of past works. When housekeeping in a work environment is poor, problems become hidden under the dirt and clutters, thereby making it possible for small potentially damaging abnormalities to develop into issues before they are discovered. The shine phase of the 5S helps to identify and get rid of these dirt and clutters and, also creates ways by which they can be removed daily and more frequently from the work environment. This can be achieved with the use of a checklist customized to specific areas, which highlights areas that should be regularly scrubbed, swept, and sanitized daily.

The emphasis of the shine process is on cleaning as a means of inspection, on cleanliness, and on creating a workplace that is impeccable.

#### **2.12.4. Seiketsu / Standardize**

To standardize means to maintain the neatness continually and repeatedly, and cleaning standards of the organization (Poornima, 2011). At this stage, the first three stages of the 5S is revisited on regular basis so that what has been done within those stages are standardized. This is to ensure that there is common standard and ways of working within the organization. Standardization is important because without a clear standard for maintaining order, and cleanliness in organisations, ways of creating accountability, monitoring adherence to rules, and making improvements would not be available. Standardization puts a structure to the 5S process and makes it possible for all employees to understand the standards set and to adhere to the standards. The role of management in the standardization process is making sure that standards are maintained by all employees including management.

To maintain standardization, two cards can be made use of with different colours (colour coded). One to note improvement opportunities and the other for 5S achievements. The emphasis of this process is on visual management and 5S standardization.

### **2.12.5. Shitsuke / Sustain**

This represents the final stage of the 5S process and means the rules should be kept so that standards can be maintained, and improvement can be continued everyday using the previous stages to maintain order and cleanliness. This can be achieved through repetition and practice thereby creating a workplace with good habits (Poornima, 2011). With this, the 5S becomes the responsibility of everyone in the organization and a part of the business culture. Having regular 5S audit and making use of reporting metrics can assist to sustain the 5S (Edwards, 2015).

Sustaining the 5S is one of the most common complaints of the 5S process. There are two major reasons for this. One being that employees do not get carried along in every step of the process, and two being that management naively assume that employees will understand the value of the 5S instantly and as such will practice it. The emphasis of this stage of the process is on creating a workplace with good habits and discipline. This can be achieved by teaching everyone in the organisation what needs to be done through training and making sure everyone practices it (Edwards, 2015). Also, 5S report boards should be established for promotion and communication of the 5S, there should be 5S slogan or logo contests, and a 5S team should be established to promote and communicate 5S issues. Through this, bad habits are broken and dropped while good habits are formed.

In the organization of a work area, the use of the 5S provides structure and discipline hence the statement “A place for everything, and everything in its place” (Mastrojanni & Abdelhamid, 2003). The first three S’s of the 5S according to Mastrojanni & Abdelhamid (2003) are easy to carry out, however, the challenge is in sustaining the effort.

Some benefits of the 5S includes improved safety, better visual management, improved and increased productivity, improved company image, boosted morale and worker commitment, waste reduction, and better customer satisfaction to mention but a few.

Now, the 5S might look and seem easy to understand and carry out, yet they can also be so difficult to achieve. Why this happens is due to so many reasons, some of these reasons are stated by Osada (1991) to includes that; people do not understand what the 5S’s are all about; nobody really works at them. Unless you really know the work inside out and have had a lot of practice, it is impossible setting up an operation and establishing the parameters. A good look at workplaces with non-performance resulting from the fact that things are not done rightly

would show some commonalities in operations. One of such commonalities would be bad interpersonal relationships where people do not even greet each other, there is high rate of absenteeism, workers don't contribute by way of suggestions as to how improvements can be made to work processes and workers within these workplaces seem not to really care about their work. Equipment's are not kept clean; you find tools not kept in places that they are supposed to be kept in but instead are all left lying around. So, companies like this would not be able to do 5S correctly as the first step to 5S is proper organisation of the workplace and that include proper interpersonal relationships between workers, proper placement of tools where they belong, etc. In organisations that are lean compliant and uses the 5S, the first indicator of how well things are going within are determined by the 5S's. If the 5S's are well implemented, things would run smoothly within but if the 5S go bad, then it means the 5S is being neglected, and therefore there is trouble. To prevent trouble, in this case to prevent the 5S from going bad, it is important to not ignore the simple things previously listed in this write up and let the problem occur. That would result to reacting to trouble after the fact. If things are put right in the right time, corrections can be made and achieved instead of prevention.

As Osada (1991) would state, in trying to produce quality products, two sets of conditions must be met if we expect to do a good job; 'we must set necessary conditions and facilitating conditions' However, Osada also stated that aside these two conditions, there is one more condition that must be satisfied; set of basic conditions. This has to do with little things like making sure that bolts are well tightened, the oil used for machines are free of impurities, etc. It is believed that neglecting these things even though they may not result to defects there and then, they will with time start showing up as defects and if not detected early they increase, and problems of different kinds starts popping up. The 5S if well implemented can help prevent all of these. In-fact, a little time spent on the 5S can result in huge savings in terms of quality, prevention of accidents, productivity, etc. A well-organized workplace according to Ehshassi & Zaiter (2014) contributes to producing products of high quality. 5S represents quality.

Several studies have discussed the relevance of 5S in promoting safety in the workplace. One of the causes of accidents identified by Howell et al. (2002) deals with materials and equipment that are placed badly in the workplace. The 5S methodology stands as a cure for this in that it leads to a well-organized construction site, which is a key factor in promoting safety and productivity of the workforce. This is because when unnecessary items that threaten the safety of employees are eliminated, and a clean work environment is maintained, the risk of accidents

are greatly reduced (Bajjou et al., 2007). Enshassi & Zaiter (2014) showed that there is a great relationship between the 5S and safety. Accordingly, Glover (2012), would state that safety stands as an essential part of the sort, set in order, and shine segment of any 5S project while standardize and sustain, points to the methods used in ensuring that good housekeeping and safety is maintained. Bashir et al. (2012) opined that the 5S can reduce the chances for occurrence of accidents on sites. Narang & Abdelhamid (2006) stated that the 5S helps in improving occupational safety (like worker exposure to hazards that could lead to injuries and fatalities) and ergonomics related issues in construction process. Yang, Zhang, & Zhang (2004) sees the 5S as a very effective safety tool and for this reason suggested that the 5S must become one of the most effective ways to take care of the problem of safety in construction sites.

### **2.13. Applications of the 5S Methodology in Construction Projects**

Even with scarcity of studies on the 5S in construction Tezel & Aziz (2016), there are a few studies that have discussed application of the 5S methodology in construction projects. Some of the implementation projects with their findings are listed below.

Mastroianni & Abdelhamid (2003) reported that the 5S even though a lean manufacturing tool can be converted into construction operations when the manufacturing version of 5S was tailored to the construction operations of Walbridge Aldinger Company. It was reported that the 5S had significant impact on the company's logistic plan. The 5S was reported to be effective as it established cleanliness on the site thus improving health and safety. One of the lessons learnt from this implementation project in Walbridge Aldinger is that a 5S plan would become useless without commitment and discipline. Furthermore, In the United State of America, Salem et al. (2005) carried out a study on implementation of lean construction tools on the first phase of a four-floor university garage project. One of the tools implemented in this project was also the 5S. It was discovered that all through the project, sort, set in order, and standardize were greatly utilized with success due to management commitments and efforts. However, traditional working behaviour became the main obstacle with the enforcement of the third stage of the 5S, which is shine and the fifth stage, which is sustain. The reason for this were twofold: the messy state of workers whereby they throw thrash on the ground during work; the belief that the reason for their employment is to do physical construction work and

not to do cleaning up. It was therefore recommended that awareness about the basic principles of housekeeping be created at all time.

Similarly, in Finland, Leino et al. (2014), carried out an implementation of the 5S methodology in a construction project with a Finnish construction firm to improve order, tidiness and especially safety performance through reducing accidents caused by slips, trips and falls. The findings from the implementation revealed that there was an improvement in safety performance, and the number of accidents resulting from slips, trips and falls reduced. However, after 3 months, a follow up on the safety performance on the site revealed that safety performance on the site was fading out. It was therefore recommended that regular engagement activities on house-keeping improvement be incorporated into the company's construction process. In the same view, Enshassi & Zaiter (2014) investigated the implementation of lean tools in construction projects and its impact on safety conditions in the Gaza Strip. The applicability of three lean construction tools were investigated. The three tools are the 5S, last planner, and increased visualization. One of the complaints of respondents in this study was that a lot of accidents and injuries that happened on the site was due to waste scattered around the site and chaos. They therefore stressed the importance of the 5S housekeeping technique in keeping the worksite safe and accident and injury free by its elimination of accidents caused by wastes. The study further indicated the relationship between the 5S and safety.

Furthermore, in the United Kingdom, Tezel & Aziz (2016) carried out a research on implementation of the visual management concept in five different highway construction sites. In one of the highways construction sites, the authors carried out an implementation of the 5S. Through the implementation, there was a 50% save in item transaction time, the useable floor area increased by 30% after applying the 5S, it helped achieve a better item flow, improved the overall neatness and cleanliness in the site, and improved health and safety. Along this line of waste reduction, Marhani et al. (2018), carried out a research on implementation of lean construction tools in some Malaysian construction projects to identify the lean construction tools that can reduce construction waste. One of the things classed as waste in this project was accident activities. All the companies that participated in this study implemented lean construction tools in the whole stage of their construction projects. Ten lean construction tools were identified across the organisations that took part in the research. Of the ten lean construction tools, three tools; daily huddle meetings, teamwork and the 5S were the most used tools for overcoming construction waste within the organisations. The research reported that



through the implementation of the lean construction tools, which include the 5S, some of the organisations were able to identify, manage and decrease all the risk associated with health and safety including having zero accidents.

### **2.13.1. Benefits of the 5S Methodology**

There have been studies that have successfully implemented the 5S Methodology (Mastroianni & Abdelhamid, 2003; Abdelhamid & Salem, 2005; Leino et al., 2014; Kabiesz & Bartnicka, 2019). Some of these studies highlighted the benefits derived from implementation of this tool. For example, Abdelhamid & Salem (2005) highlighted some of these benefits to include bringing improvement in safety performance, improvements in productive and quality, improvements in set-up-time. The tool helps with space creation and improve the moral of workers, including teamwork improvement. Also, the implementation of this tool helps to reduce lead times and cycle times and helps with continuous improvements. Furthermore, Falkowski & Kitowski (2013) highlighted the benefits of the 5S in different work activity areas. In the area of health and safety, the tool brought about a reduction in the rate of accidents and provided more security. In the area of product quality, the implementation of the tool helps with higher product quality, including improved quality of activities within production unit. Also, the tool brought about improved working conditions for workers and created a better work atmosphere. Regarding labour productivity, the tool made work organisation better, it helped to reduce time wasted looking for materials and items and it brought about better cooperation between employees. Importantly, the tool also helps to improve communication between workers and their managers, the cleanliness of machines and work devices are maintained by the application of the 5S thereby leading to reduction in the failures experienced with machines and tools (Kabiesz & Bartnicka, 2019). Economically, it has also been proven that the implementation of the 5S is relatively inexpensive when the amount spent in its implementation is compared with the benefit derived from its successful implementation (Falkowski & Kitowski, 2013).

A Look at some of the studies that have listed the benefits achieved appear to all have similar outcomes as seen in the few studies outlined above. A summary of these benefits is therefore listed below in no particular order.

1. The 5S brings about decrease in non-value adding activities and excess inventory. Examples of such non-value adding activities includes motion wastes, searching, thinking, guessing, etc.
2. The 5S brings about increase in usable workspace.
3. Improvement in health and safety conditions including reductions in site accidents.
4. The 5S ensures machine reliability.
5. Productivity, quality, and set up time improvement.
6. It brings about a workspace where all defaults are made obvious.
7. It brings about reduced lead times, and cycle times.
8. It brings about an easy to understand workshop.
9. It brings about elimination of defects.
10. The 5S makes it possible to distinguish dangerous places from safe places.
11. It brings about elimination of picking up and setting down waste.
12. It brings about prevention of break downs.
13. It brings about proper storage of inspection gear.
14. It eliminates searching waste.
15. Leads to increased machine uptime.
16. It makes equipment last longer.
17. The 5S makes it possible to eliminate unnecessary inventories.
18. It clarifies where to put work things.
19. It eliminates equipment that are not needed.
20. Product diversification.
21. Lower cost.
22. Improved morale, teamwork, and continuous improvement.
23. Reliable deliveries.
24. Higher availability rate.

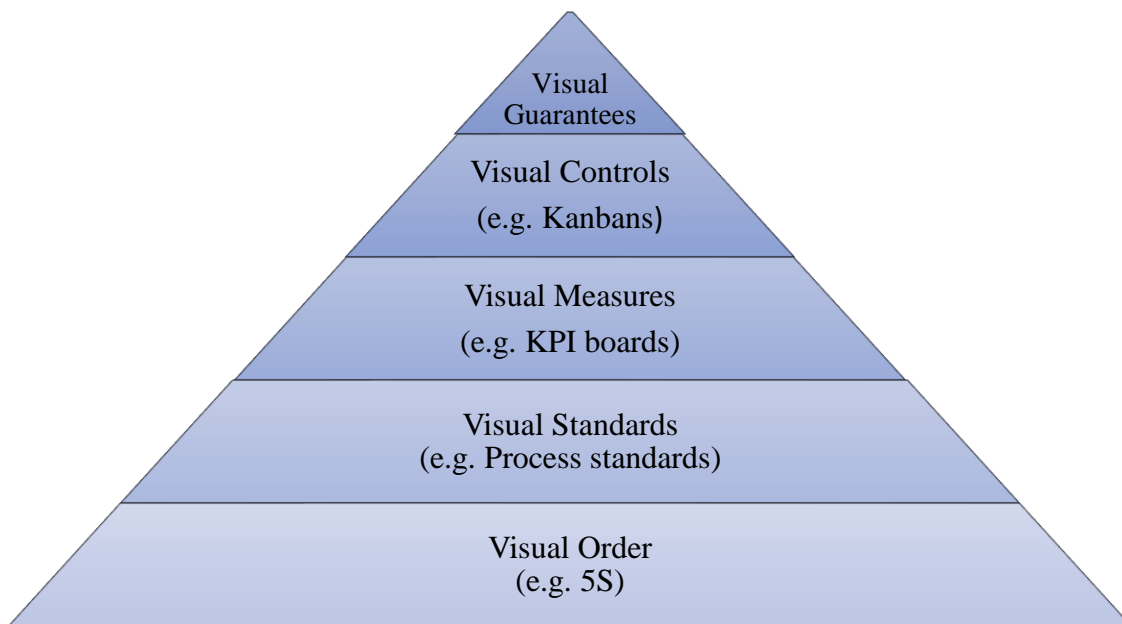
## **2.14. Visual Management as a Lean Tool**

Visual management is an essential element of, and one of the functional blocks of lean production philosophy (Tezel et al., 2015). It is a system that provide real-time information on workplace status by a combination of simple, effective visual information aids, which allows employees to understand their influence on the organization overall performance hence

allowing the employees to improve their performance (Shmula, 2012). Furthermore, Tezel et al. (2009) defined visual management as a management system that attempts to make organizational performance better through connecting and aligning organizational vision, core values, goals and culture, with other management systems, work processes, workplace elements, and stakeholders, by means of stimuli, which directly address one or more of the five human senses (sight, hearing, feeling, smell, and taste). In relation to construction, visual management refers to the managerial strategy of consciously integrating visual tools in workspaces with the aim of increasing transparency in construction sites (Tezel et al., 2015). It is classed as a way of communicating information using the right visual tools at the right time, for the right situation in all construction projects (Abdelkhalek et al., 2019). Visual management supplement work instructions through reinforcing the right way that things should be done at the point of action. It helps in ensuring that the right things are being done the right way by people, at the right time, and for the right reasons even when no one is watching (Kovera, 2014). Within organizations, visual management serves different functions. These functions include transparency, discipline, continuous improvement, job facilitation, creating shared ownership, on the job training, management by facts, simplification, and unification (Tezel et al., 2009).

Within these definitions and explanations, one important point stands out: the information quality of visual management. Making information easily accessible with a view of making process participants to act in purposeful ways (Brady, 2014). The major principle behind visual management is that people are usually attracted by what they see (Ho, 1993). This can come in form of notice board, indication light, slogan, card (kanban), visual display unit, etc also known as visual aids, with the objective of making communication simple and attractive such that it is transparent to all by use of these visual aids. Grief (1991) describes the source of information rendered by visual management in communication process as the as the space or environment to people mode of communication. The space represents the ‘source’ and people represents the ‘recipients’ (Tezel et al., 2015). Some ways by which these two interact are through architectural design; through physical artefacts fixed firmly into the environment; and through digitally augmented artefacts like electronic posters on the wall. All these lead to the realization of a visual workplace (Tezel et al., 2013). Accordingly, Bevilacqua et al. (2013) would describe a visual workplace as “a self-ordering, self-explaining, self-regulating, and self-improving work environment – where what is supposed to happen does happen, on time, every time, day or night – because of visual solutions”. The visual workplace bases itself on 5S pillar of sort,

set in order, shine, standardize, and sustain (Hirano & Talbot, 1995). The Figure (3) below adapted from Galsworth (2005) represents the visual workplace framework



*Figure 3 Visual Workplace Framework (Galsworth, 2005)*

Starting from the bottom and moving upward, visual order represents the systematic standardization, including cleaning of workplace, tools, materials, warehouse, etc. This basically involves applying the 5S concept (Tezel, 2015). Next is the visual standards, which basically involves provision of visual standards and displays to people to use in the various task. Here things like written specifications, procedural standards and many more are made use of. This level also involves the application of various tools that make information readily available such that process participants can answer core questions of where, what, when, and who with regards to effective decision making (Brady, 2014). Next level on the framework is visual measures, which involves the open display of various performance figures in an easy to understand fashion. Next level is the visual controls, which limits, tracks and regulate behaviours generally for production management (Tezel, 2015). Here things like the Kanban cards are used. The last level is the visual guarantees, which are basically mistake proofing devices like poka yoke, specifically used for error minimization (Brady, 2014). Importantly, implementing each layer of the framework starting from bottom to top is the step to creating a visual workplace.

In practice, the first step towards the implementation of visual management deals with applying the 5S methodology. This is because the 5S helps to get rid of clutters from the work site,

improve the use of space and it introduces standards, all helping to visually improve the workplace. Visual management builds on the fourth “S”, which is ‘standardize’ by showing how to do the job based on standard, agreed upon best practice. There are three basic steps required in visual management. First is to organise the workplace using the 5S, then ensuring that all required work standards, instruction, and related information are clearly displayed in the workplace. Finally controlling the workplace processes through exposing and stopping errors and by preventing future occurrences (Syed, 2014).

Visual management goals are achieved through using one or a combination of four different types of visual tools: visual indicator, visual signal, visual control, and visual guarantee. More details about these tools are stated below from the work of Tezel et al. (2015).

- Visual indicators: These are used for the purpose of displaying information. Compliance or adherence to the displayed content is voluntary. Examples are safety advisory boards or traffic signs. They are very useful for communicating important information from management to operational level.
- Visual signal: These are used for the purpose of first catching the attention of people and then delivering its message for an action. Example sirens of trucks in movement on site, traffic light. This tool performs two important functions: encourages workers to attention and direct workers behaviour.
- Visual controls: This tool has the function of impacting behaviour through structuring or building a message directly into the physical environment by putting physical limits in place. Examples are speed bumps, road lines etc.
- Visual guarantee also known as poka-yoke device: Has the function of guaranteeing that only the right thing happens. Example is electronic circuit that makes it impossible for lifts to move when the door is open.

### **2.14.1. Application of Visual Management in Construction Research**

Within the construction industry, it has been stated that visual management is not well known, however, the importance of visualization is well recognised based on some studies (Tjell & Bosch-Sijtsema, 2015). Formoso et al. (2002) investigated how the principles of process transparency can be applied in construction sites, as well as the existing implementation barriers. Heineck et al. (2002) carried out a case study on transparency in building construction

and concluded that majority of the innovations introduced on the site increased transparency and visibility of operations.

In like manner Brady et al. (2012) presented a case study on how the development and implementation of visual management method was used to improve transparency in a construction site with similar results. Furthermore, the importance of visual management as a communication tool has been demonstrated (Bust et al., 2008). It is believed that when different people from different countries with different languages work together in a site, the opportunity for messages to be lost in translation increases. This can affect workers participation in managing safety on site because participation is needed to build ownership and responsibility. Bust et al. (2008) investigated the importance of using visual management on construction sites that employ migrant workers, especially those with communication barrier. It was noted in this study that one of the major barriers to health and safety in construction sites is the inability of workers to directly communicate via spoken words. Authors therefore emphasized the value derived from the on-site use of audio/visual devices that are culturally suitable for migrant workers, which do not require full language competence regarding communications especially relating to health and safety on site. Tezel et al. (2013) investigated visual management realisation means and attributes in the construction process of a large industrial facility involved in electrical and construction work. Murata et al. (2016) used an analytical framework from manufacturing to investigate visual management cases in construction. Tezel et al. (2017) investigated the current visual management practice in highways construction project in England. Awada et al. (2016) stressed that the use of visual tools for communication of important safety instructions on sites is the major key for maintaining safe construction environment. Abdelkhalek et al. (2019) conducted an analysis of visual management practice in Lebanon for construction safety and advised construction firms to make use of visual tools in their sites to educate workers on safety and to direct workers actions and behaviour.

The essence of the above paragraph is to draw attention to some of the studies on visual management in construction projects. Furthermore, studies have shown the success derived when visual management are implemented in construction sites.

In the City of Fortaleza in North Eastern Brazil, Heineck et al. (2002) carried out a case study on transparency in a building construction. Based on this implementation process, several innovations were introduced in the site. Findings from the study revealed that these visual innovations introduced increased transparency and visibility of operations and safety was

improved in the site. In like manner, In the United State of America, Salem et al. (2005) carried out a study on implementation of lean construction tools on the first phase of a four-floor university garage project. Several lean tools were implemented including the increased visualization lean tool. Throughout the stages of this implementation project, different combinations of visual signs like safety signs, completion date signs, and PPC charts were tested. It was discovered however that in the starting phase of the project, the signs needed for increased visualization did not get the required attention from the project management. A few safety signs were however posted within the project site. Findings revealed that towards the end of the project, there was a significant increase in the level of visualization. But this significant increment was due to the continuous effort put in by the team conducting the research.

Jang & Kim (2007) carried out three case studies with three different construction companies working in a heavy civil construction project on the use of Kanban system for production and safety control. In these projects, the Kanban system was made use of as part of the Last Planner System and was implemented primarily to improve workflow reliability and safety record. As part of the implementation process for the Kanban system, training session was conducted in each of the three project sites by the authors, in which the Kanban implementation was discussed, and workers gave their opinions about using the system. Findings from the study revealed that the Kanban system increased workflow reliability. There was an improvement in the monitoring of the percent planned completion (PPC) due to continuous trainings that were being held while the project was on, and the fact that review of the PPC and work plan was carried out together by the office controller and field engineer. Due to implementation of the Kanban system, there was a decrease in the number of safety related Non-Conformance Reports. In terms of safety related accident rates, there was a great reduction in accidents as it decreased by 33% in the six-month period for which the project was on, with only thirteen minor accidents after the implementation of the Kanban system. In-fact, it was also reported that in Case Studies A and B, there were no accidents.

Tezel et al. (2011) examined the visual management conditions and the realization of a visual workplace framework on 5 different Finnish Construction sites belonging to five prominent construction companies in Finland. Findings of the study revealed that visual management strategy is at the initial level with effort based on initiatives of individuals and not on systematic company approach. For example, for case study 1, visual communication systems were devised

by different work groups for themselves, which mostly were unknown to the site management. In case study 2, a worker took it upon himself to consistently display information around the site. This was a personal effort made by an individual and not an initiative initiated by the company. Furthermore, to solve a practical problem in a construction project in Germany involving a general lack transparency in the daily operations on site, Brady et al. (2012) developed a visual management method and implemented same. Due to this lack of transparency, other problems like lack of communication, absence of clear responsibilities, slowness in making decisions, unsatisfactory interfaces between planning and contracting companies, too many information, lack of process orientation and perception of quality have cropped up. Hence the need for the development and implementation of the visual management method with a basic goal of creating a method to improve transparency on the site. To achieve this, visualized daily planning system was introduced. Findings revealed that through the display of the daily work packages on the construction board situated at the central area of the building and, which serves as the physical main meeting point for all involved in the project, communication was improved made simpler. Also, findings revealed that the combination and use of different visual aids helped support continuous improvement of quality within the visual management method and ensured that reaction to quality problems were timely such that rectifications were made on problems while contractors are still on site. This helped save time and prevent spreading of the problem to other areas. Lastly, findings revealed that with performance measurement, there was an improvement in delivery date performance.

In 2013 in Brazil, Tezel et al. (2013) investigated visual management realisation means and attributes in the construction process of a large industrial facility involved in electrical and construction works. In doing this, authors studied the visual management approach of one of the subcontracting companies in the project. Findings from the study revealed that standardization of workplace element level was high due to the high number of visualizations of work processes. There was no trace of the Kanban system in place on the site. Regarding health and safety, the findings revealed that there was presence of static and mobile safety signs on the site, also, there were visual reminders, colour coded equipment checking system, colour coded scaffolding safety tags, gas leakage wind roses, safety barriers, posters and lots more. For the crane boom safety, there was the poka-yoke system, which was incorporated into the cranes in use. The system locks the crane boom in the case of uncertain conditions. Overall, the use of visual signs in the site was rich even though most of the reported visual signs were health and safety related. Thus, it was concluded that visual management does exist in



industrial construction sites. Along the line of safety, Enshassi & Zaiter (2014) investigated the implementation of lean tools in construction projects and its impact on safety conditions in the Gaza Strip. The applicability of 3 lean construction tools were investigated. The three tools are the 5S, last planner, and increased visualization. Findings revealed that companies investigated used signs and labels around their sites. These signs related to safety, quality, and performance. The study also found that there was limited use of visual tools for communication between workforces in the project. Lastly, it was also discovered from the study that strong relationship exists between bad visualization and occurring accidents on the construction sites. Furthermore, visual management practice was investigated in Lebanon construction sites (Abdelkhalek et al., 2019). Finding from the study indicated that visual management is an important lean tool for maintaining safety in construction. The finding also outlined that poor visualization causes a lot of accidents in construction sites. It was also established in the study that lack visual management was the reason for lack of safety in some of the sites investigated (Abdelkhalek et al., 2019).

### **2.15. A3/PDCA Problem Solving Framework as a Lean Tool**

The success Toyota Motor Cooperation have had over companies like Ford, General Motors, and in manufacturing today is pulled from a management philosophy and culture that is grounded in the Plan-Do-Check-Act (PDCA), which is aligned with Toyota Business Practice and the A3 report template (Schwagerman & Ulmer (2013). Toyota's practice of the Plan-Do-Check-Act (PDCA) stands as the driving force of the use of lean manufacturing and can according to Schwagerman & Ulmer (2013) be captured in an A3 proposal. The term A3 according to Shook (2008) refers to an international size piece of paper, approximately 11 by 17 inches in size, with a solid structure for the implementation of the PDCA management (Schwagerman & Ulmer, 2013). The A3 report represents a tool used at Toyota for problem solving. Shook (2008) defines it as a visual manifestation of a problem-solving thought process involving continual dialogue between the owner of an issue and others in an organisation. Shook (2009) defines a problem as something that brings itself up as a barrier to the organization achieving its goal. An A3 basically lays out entire plans or reports, big or small, on a sheet of paper, and tells a story, which can be understood by anyone (Schwagerman & Ulmer, 2013).

The A3 is made up of a sequence of boxes arrayed in a template with the following element (title, owner/date, background, current conditions, goals/targets, analysis, proposed counter measures, plan, and follow-up). Shoot (2008) explains each of the element below.

- **Title:** This is where the problem, theme or issue should be named. It should give a description of the specific problem being addressed and must answer the basic question: *What does the A3 owner want to talk about, to propose?*
- **Owner/Date:** This is the part that identifies who ‘owns’ the problem or issue and the date of the latest revision. It must be signed, with initials and dated by the person who is taking responsibility for the problem or proposal.
- **Background:** This is the part where the business context and importance of the issue is established. The part where the need for the problem to solved is defined. It must answer the basic question: *Why am I posing this problem? What is the broader business context of the issue?*
- **Current Conditions:** This the part where what is currently known about the problem or issue is described. This comes from facts acquired from the place where the work is taking place (gemba). The owner must carry out careful investigation to get the real facts about the real work to know the current conditions.
- **Goals/Targets:** This is the part where the desired outcome is identified. Desired targets are identified and listed.
- **Analysis/Root Cause:** This is the part where the situation and root causes that have created the gap between the current situation and the desired outcome is analysed. The root cause is identified by examining the way the work is currently being performed and asking why the problem occurs. With clear definition of the root cause, effective countermeasures can be developed.
- **Proposed Countermeasures:** This is the part where some corrective actions or countermeasures are proposed to address the problem, close the gap, or reach a goal. It refers to the way that proposed actions are directly addressed to existing conditions.
- **Plan:** This is the part where action plans of who will do what, when, to reach the goal is prescribed.
- **Follow-up:** This part creates follow-up review/learning process and anticipates remaining issues.

The elements in the A3 flow with one another in a natural and logical sequence. The links among the problems, the root causes, the goal, actions proposed to make the goal achievable, and the means of judging success are clear and not difficult to understand. In using the A3, it must be understood that there is no one fixed correct template. Whoever oversees the A3 decides what to highlight based on the specific situation and context.

A3 serves as a means by which managers can give mentorship to others on root cause analysis and scientific thinking, while also giving support to the interest of individuals and departments in the organisation by encouraging productive dialogue and helping individuals learn from each other.

A very good way to describe the A3 was given by Shook (2009).

*“The A3 is a standardized storytelling, which refers to the ability of A3s to communicate both facts and meaning in a commonly understood format. Like any narrative tale, an A3 tells a complete story, with a beginning, a middle and an end, which can be traced from the upper left-hand side to the lower right side. Because readers are familiar with the format, they can focus easily on the matter contained. It becomes the basis for reaching a shared understanding”*

This ability of the A3 in solving problems, through arrays of elements in a step by step format made Shook (2008) to suggest that the A3 should be made a standardized form of currency for problem solving, dialogue, and decision making in organisations. The key to the entire A3 process is about seeing the right problem and being able to accurately define it. Without this, whatever is done in the A3 would amount to nothing.

The main goal of the A3 according to Shook (2009) aside solving problem at hand is to make problem solving process transparent and teachable in a way that creates an organization full of thinking and learning problem solvers. Through this, the A3 management process powerfully shows the essence of operational learning.

Some important benefits of the A3 listed by Sobek & Smalley (2008) and William (2010) are that:

1. The A3 establishes a concrete structure for the implementation of the PDCA management.

2. The A3 helps draw the authors of the report to a deeper understanding of the problem or opportunity, as well as, gives authors insight as to how to address the problem.
3. The A3 facilitates cohesion and alignment within the organization with respect to the best course of action.
4. The A3 helps in improving collaboration, outcomes and problem solving of specific issues.
5. The A3 helps promote deliberative, thoughtful decision making.
6. The A3 helps with root cause identification.
7. The use of the A3, helps with information and knowledge sharing among team members.
8. The A3 creates and serves as a dashboard of useful information to reference throughout the stages of the whole project.
9. The A3 helps with the provision of historical record of issues in projects.
10. The A3 helps with the provision of concise project update for top management and promotes faster input and feedbacks.

What matters most about the A3 report is not the format of the report itself but the underlying thinking that leads the participants through a plan, do, check, act (PDCA) cycle (Shook, 2008). This underlying thinking is what makes up the critical core strength of a lean company.

The Plan-Do-Check-Act (PDCA) is a system, used for the continuous improvement and management of organizations, and the purpose of the A3 is to document on one page, the results from the PDCA cycle (Schwagerman & Ulmer, 2013).

An explanation of the workings of the PDCA in collaboration with the A3 is given below from the work of Schwagerman & Ulmer (2013).

The PDCA process starts with the “Plan” phase. This phase states the problem clearly and objectively, it also gives some background and context about the problem so that everyone involved have a common understanding of the problem and the root cause identified. The “Plan” phase covers the “background, current condition, goal, and analysis” parts of the A3 report.

The “Do” phase of the PDCA takes the hypothesis and test same by scientific method. If there is need for improvement, it is in this phase things are changed and adjusted. During this phase,

accurate data is retrieved from the place the work is being carried out, commonly called 'Gemba' by the Japanese. The "Do" phase covers the "countermeasures" part of the A3 report.

The "Check" phase is basically initiated for the purpose of studying the effects from the "Do" phase. Here, facts are made known, analysed, and discussed for determining what worked and what did not work. The "Check" phase covers the "plan" phase of the A3 where confirmations are put into effect.

The "Act" phase is the phase designed to identify things that worked and things that did not work, and why. This phase is sometimes referred to as "analyse". Here if results come out good, the team will find out how to standardize and share the success, and this also involves going through the PDCA cycle for further improvements. If the result comes out poor, the team will determine ways to prepare for a repetition of the PDCA cycle again.

The "Plan" phase of the PDCA stands as the half that is most heavily weighted in the A3 report format. As seen in diagram below, it contains the background section, current condition, future state also referred to as goals/targets, and the root cause analysis.

The background section is the first step addressed on the A3. It spells out the information needed to understand the extent and importance of the problem. According to Sobek & Smalley (2008) to get optimum value, the author(s) of the A3 must know his or her audience and the background must be connected to the goals of the company (Schwagerman & Ulmer, 2013). The second step addresses the current condition section of A3/PDCA. Schwagerman & Ulmer (2013) suggest that this should be done using words or pictorially using a Value Stream Map (VSM). The importance of using visual explanations for effective A3 writing has been stated by Sobek & Smalley (2008). This includes the use of charts, diagrams, and graphs. The third step according to Schwagerman & Ulmer (2013) should address two basic issue that define project success at the conclusion of implementation, including what will be used as a basis for comparison. It should identify the gap between current and future goals. The fourth step deals with the investigation of the current condition section of the A3 for identification of the root cause of the problem. The technique commonly used for this investigation by lean practitioners is the "5Whys". This tool is also heavily emphasized by Toyota. Also, the Fishbone diagram method, also known as "Ishikawa", is used.

The "Do" phase of the PDCA commences in step five. This is stage where the gap between current condition and future condition is closed. This occurs in the countermeasures section of

the A3. The countermeasures section focuses on proposed improvements and is made up of an action list for solving the problem. The early stages of the countermeasures section involve outlining an action plan, which would include tasks, people involved, and completion schedules. The “Check” phase of the PDCA is in step six. In the A3 report this is seen in the “Effect Confirmation” section. This simply involve checking results. The “Act” phase is step seven, which is simply to show any further changes or adjustments in the “follow-up” section of the A3 (Schwagerman & Ulmer, 2013). Figure 4 below is a sample of the A3/PDCA report format adapted from Schwagerman & Ulmer (2013).

Problem Solving A3.					
Countermeasures					
<b>Background.</b>  <div style="text-align: center; font-size: 2em;">P</div>	Suspected Cause	Action Item	Responsible	Due	Finding
	1				
	2				
	3				
	4				
<b>Current Condition.</b>  <div style="text-align: center; font-size: 2em;">L</div>	5				
	6				
	7				
<b>Effect Confirmation.</b>					
Check					
<b>Goal/Targets.</b>  <div style="text-align: center; font-size: 2em;">A</div>	<b>Follow-Up Actions.</b>				
	Investigation Item	Responsibility	Due	Status	
	1				
	2				
	3				
	4				
	5				
	6				
7					
Act					
<b>Root Cause Analysis.</b>					
N					

Figure 4 A3/PDCA Format (Schwagerman & Ulmer, 2013)

## 2.16. Chapter Summary

This chapter started by presenting a review of literature on the sociotechnical systems theory, which was borrowed as the umbrella theory for the research to understand and explain the problems associated with construction safety regarding accidents and their root causes and how they can be mitigated using lean practice. It was explained that traditional research on workplace safety only focus on the individual without taking the broader sociotechnical aspects of the work environment surrounding the workers into perspective. However, sociotechnical systems theory was explained to be an approach that considers human, social, and organisational factors as well as technical factors in the design of organisational systems. Hence, the justification to borrow the theory.

The chapter then reviewed health and safety in the Nigerian construction industry. In this review, it was outlined that health and safety in the construction industry in the country is poor especially with indigenous construction firms hence the frequent accidents in the industry leading to injuries, illness and even death. Following this, the chapter reviewed literature on the root causes of construction accidents and found seven main root causes: (i) lack of knowledge and training (ii) non-provision of safety equipment and materials (iii) workers attitude and behaviour (iv) deficiencies with enforcement of safety (v) lack of safety management (vi) working long hours and overtime, and (vii) workplace factors such as poor housekeeping, space availability, et al. Furthermore, the chapter reviewed literature on lean construction and its tools, including implementation of some lean tools to improve construction safety in construction projects in other parts of the world. These studies established that lean tools can be applied in construction projects to improve safety performance by eliminating or decreasing the occurrence of accidents that harm workers. Hence, in figure 5 below the conceptual framework developed in figure 1 was updated to include the seven root causes of construction accidents identified from literature in this study.

Based on this, the study sort to apply lean tools in developing a safety framework that construction firms in Nigeria can make use of to improve safety performance on site. This will be achieved through interviews with Nigerian construction workers at labour and management levels to find out what the root causes of construction accidents are in the Nigerian construction industry. Hence the next chapter will discuss the methodology being applied in this research focusing on the qualitative research methodology.



# Sociotechnical Systems Theory

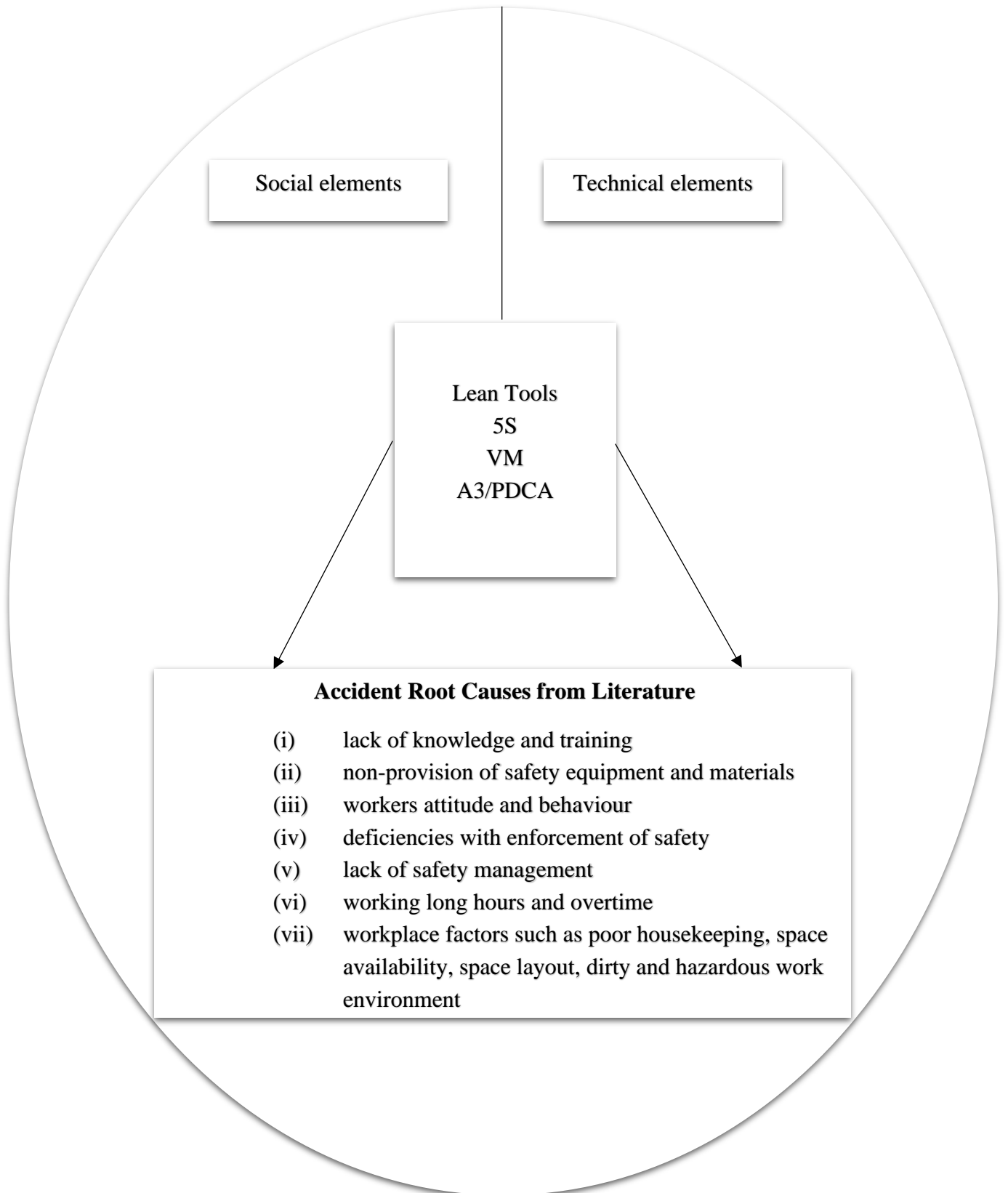


Figure 5 Updated Conceptual Framework

### **3. Chapter Three – Research Methodology**

This chapter describes in detail the methodology used in conducting this research. The research is based on the constructivist and interpretivist philosophical paradigms which are synonymous with qualitative research. The research therefore uses a qualitative approach, through multiple case studies design, to understand how the adoption of lean practice can be applied in a safety system to mitigate accident root causes in the Nigerian Construction Industry. To achieve this, the research employed the use of semi-structured interviews and non-participant observation as data collection means to elicit rich in-depth theory driven data from participants. In all, twenty-seven semi-structured interviews were conducted with small and medium scale indigenous construction firms in Nigeria. Theoretical sampling method was employed to select participants for the study, and the rich data collected from participants were analysed using thematic analysis method. The chapter therefore discusses the various methods applied in conducting this research and the rationale behind the use of each of these methods and ends with the ethical practice applied in the study.

#### **3.1. Research Philosophy**

Research philosophy according to Saunders et al., (2009) refers to a system of beliefs and assumptions about the development of knowledge. Whenever a research journey is embarked on by a researcher, the researcher develops knowledge on that field. As the research progresses, many assumptions are made. Assumptions relating to the form and nature of realities and what can be known about it, which is referred to as ontological assumptions (Guba & Lincoln, 1994). Assumptions relating to human knowledge and how we know things, which may be referred to as epistemological assumptions (Matthews & Ross, 2010). These assumptions according to Saunders et al., (2009) is what shapes the way we understand our research questions, methodologies, and the way we interpret our findings. Leavy (2014) would state that these two assumptions guiding research practice serves as the philosophical basis of any research practice. They are discussed below.

### **3.1.1. Ontological Position and Assumption**

Leavy (2014) defines ontology as a philosophical belief system that is concerned with the nature of social reality, and this includes what researchers can learn about this reality and how researchers can do so. The general aim of ontology is to provide general accounts of the nature of social reality (Given, 2008). The key ontological questions within social research according to Ritchie & Lewis (2003) are concerned with whether social reality exists independently of human conceptions and interpretations or not; whether there is a common, shared, social reality or just multiple context-specific realities; and whether, or not social behaviour is governed by laws that can be seen as unchallengeable or generalizable.

The ontological assumption of a researcher shapes the way the researcher sees and studies his or her research object. Saunders et al. (2009) states these objects to include organisations, management, individual's working lives, and organisational events and artefacts. Therefore, the researcher's ontology determines how the researcher sees the world of research and in this way determines the researcher's choice of what to research in his or her research project (Saunders et al., 2009). Three ontological positions exist in relation to the nature of the social world and what there is to study. They are objectivism, constructivism, and realism (Matthews & Ross (2010).

The position based on objectivism is that "the social phenomena that makes up our social world have an existence of their own, apart from and independent of the social actors (humans) who are involved" (Matthews & Ross, 2010). Therefore, the relationship of the social researcher to the social world and the social phenomenon being studied is one of objective observation. This approach is that often taken by the natural scientists.

The position based on constructivism is that "the social phenomena making up our social world are only real in the sense that they are constructed ideas which are continually being reviewed and reworked by those involved in them (the social actors) through social interaction and reflection" (Matthews & Ross, 2010). In constructivism, social reality does not exist apart from the meaning of the social phenomenon for the participants, however, the meaning ascribed to and the understanding of a social phenomenon which are constructed by the social actors are available for study. Here, the social researcher who also is a part of the social world brings her own meaning and understanding to her study.

The position based on realism is that “the social world has a reality that is separate from the social actors involved in it, that can be known through the senses as well as the effects of hidden structures and mechanism” (Matthews & Ross, 2010).

It has been explained by Creswell & Clark (2018) that our ontological assumptions should be coherent with our research question. Therefore, this study employs the constructivist paradigm to investigate how the adoption of lean practices can be the foundation for a safety system in Nigeria construction industry.

According to Guba & Lincoln (1994), the goal of constructivist researchers is on understanding and reconstruction of the constructions (meanings) that people (including enquirer) hold about the phenomenon being studied, as their interpretations and information improve. Knowledge is created by constructivist through interaction, i.e., interaction between the inquirer and the research participants, by dialectical process and understanding (Guba & Lincoln, 1994; Kim, 2001). Furthermore, for the constructivist researcher, the sources of data are frequently returned to, to find out what the data mean to the participants of the study and trying to integrate those with their meaning to the researcher (Rudestam & Newton, 2014).

The health and safety issues regarding accidents and their root causes in the Nigerian construction industry is a huge problem that has and continues to result in so many ill health, injuries and even death to construction workers. Therefore, regarding this study, in-depth, semi-structured interviews were conducted with twenty-seven participants from three small-scale and three medium scale indigenous construction companies in Nigeria to through dialectical process find out what the root causes of construction accidents are, with a view to applying lean tools to in a safety framework to mitigate these root causes. Data from participants in the study were continually examined as means to understand and construct meanings of participants perception of accidents and their root causes. The approach and method applied in this study were guided by the research question:

*How can the adoption of lean practices be applied in a safety system to mitigate accident root causes in the Nigerian Construction Industry?*

### **3.1.2. Epistemological Position and Assumption**

In its simplest form, epistemology refers to the nature of knowledge and how it can be acquired (Ritchie & Lewis, 2003). Burell & Morgan (2017) gave a broader definition: “Epistemology refers to assumptions about knowledge, what makes up acceptable, valid and legitimate knowledge, and how researchers can communicate knowledge to others. Leavy (2014) explains that epistemology is a philosophical belief system about how research proceeds as an embodied activity, how an individual embodies the role of a researcher, including the relationship between the researcher and the research participants. Also, Leavy (2014) citing Guba & Lincoln (2008), and Ponterotto (2005) defined epistemology as “the study of the process of knowing or how we know what we know” Epistemology is primarily concerned with how knowledge of what exists is gained by researchers and the relationship between the researcher (the knower) and the world. Epistemology focuses on questions like: how can we know about reality and what is the basis of our knowledge?

There are two main epistemological stances: positivism and interpretivism. These two are explained below relying on Richie & Lewis (2003). The positivism stance believes that methods used in the natural sciences can also be applied in research dealing with social enquiry. This is based on a believe that law-like regularities govern human behaviour, and that carrying out independent, objective value free social research is possible. Positivism is associated with quantitative research. Within this approach, quantitative data are collected, aspects of the social world, social phenomena are measured, causal relationship between different aspects of the social world are sought and large data sets and statistical analysis are often made use of.

Interpretivism on the other hand opposes this view and claims that the methods applied in natural science are not appropriate for social investigations (Matthews & Ross, 2010). This claim is based on the belief that the social world is not governed by regularities that hold law-like properties. This is the reason why researchers in the social field must explore and understand the social world through their own perspective and the perspective of the participants (Richie & Lewis, 2003; Matthews & Ross, 2010). Interpretivism is associated with qualitative research.

Based on the aim of this research, this study will assume the interpretivist stand.

By taking the interpretivist approach in investigating the health and safety issues regarding accidents and their root causes in the Nigerian construction industry, the researcher can base his understanding of what constitute acceptable knowledge about this phenomenon as being subjective meanings. The researcher gets this subjective meaning by getting as close as possible to the construction workers being studied and try to get into their head to be able to speak, to understand, and interpret what the construction workers, who are the participants in this research are thinking, or the meaning they make of the accident phenomenon. This the researcher achieved through in-depth interviews. The effort of the researcher in this case is placed on understanding the viewpoint of each of these workers and their interpretation of the health and safety phenomenon of accidents and their root causes being studied. By doing this, reality can be constructed socially, and the researcher can make meaning of the data collected through his own thinking, informed by the interactions with the construction workers. Furthermore, through this, the accident phenomenon can be deeply examined, and the researcher can, from the rich and detailed data gathered, develop theory by developing a conceptual lean safety framework that organisations can make use of to diagnose and mitigate accident root causes in the Nigerian construction industry.

For the above reasons research, the researcher therefore chooses the interpretivist position as the epistemological standpoint to study and address the research question; how the adoption of lean practices can be applied in a firm's health and safety system to mitigate accident root causes, with a means to providing a safety framework that organisations can make use of in mitigating these root causes. Qualitative data was collected majorly through semi-structured in-depth interviews, backed with non-participant observation. This qualitative research was carried out with the researcher taking active part in the whole process of its development.

### **3.1.4. Axiology**

Axiology is a branch of philosophy that studies the role value plays in research (Creswell & Poth, 2018). It is specifically focussing on what a researcher values in his or her research, and includes both ethics and aesthetics (Chopra, 2005). In other words, it refers to what a researcher believes is valuable and ethical (Killam, 2013). Kivunja & Kuyini (2013) explains that axiology deals with defining, evaluating, and understanding concepts of right and wrong behaviour as they relate to our research. This value, extends to that, which a researcher attributes to different

aspects of their research, i.e., the participants, the data, and the audience the report of the research will be reported to (Kivunja & Kuyini, 2017). Axiology ask and address questions about what the nature of ethics or ethical behaviour are. i.e., what do researchers consider to be good or bad; right or wrong. Axiology also ask questions about the extent to which our research can be totally neutral or if the personal values or opinion of a researcher come into play or shape how he or she conduct their research.

These are all considered in this research. From formulating the interview questions based on the phenomenon under study, deciding the interview method, and writing the interview guide, participants were taken into consideration and all ethical principles considered and applied. This is highlighted in the ethics section of this chapter. Furthermore, the researcher ensured that every action taken regarding this research in terms of methods specified in this chapter (chapter 3) were action taken with the goal that they will be of beneficial value to the research participants, scholars, the public at large, including the researcher himself. Morality in terms of truthfulness in interpretation of data was also considered by the researcher. Interpretations of data was done without bias and all data were interpreted based on truthful evidence from the data collected. Furthermore, in dealing with each research participant for the study, the researcher was fair to every participant and showed no favouritism or discrimination towards any of the participants and treated all participants in the same way.

### **3.2. Qualitative Research Approach**

Choosing a research approach for any study is always not an easy challenge largely due to the various debates surrounding the various research approaches that exist regarding which is best to make use of in one's research project. There are three ways in which research can be investigated. It could be by qualitative, quantitative, or mixed approach. Based on the merits and the demerits of the three approaches, no approach is better than the other. According to Kumar (2011), the approach a researcher decides to make use of depends on the objectives of the study. Therefore, based on the objectives of this study, the ontological and epistemological standpoint of the researcher which are constructivist and interpretivist, the qualitative research methodology was chosen for this research. The rationale behind choosing the qualitative approach is discussed along with the discussion of the qualitative research method below.

Qualitative research according to Hennink, et al. (2010) is an approach that allow one to examine people's experiences in detail, by some specific sets of research methods such as in-depth interviews, focus group discussions, observation, content analysis, visual methods, and life histories or biographies. Leavy (2014) describes qualitative research as a way of learning about social reality and states that the approach can be used across disciplines to study a wide range of topics. For example, this approach to research is used in social and behavioural sciences to explore, describe, or explain social phenomenon; unpack the meaning people ascribe to activities, events, situations, or artefacts; build a depth of understanding about some aspect of social life; build thick descriptions of people in naturalistic settings; explore new or under-researched areas; or make micro-macro links (illuminate connections between individuals-groups and institutional and/or cultural contexts) (Leavy, 2014). Creswell (2009) refers to the qualitative approach as social constructivism and interpretivism.

A distinctive feature of the qualitative research is the ability to allow the researcher to identify issues from the perspective of his or her study participants and understand the meanings and interpretations that the participants give to behaviour, events or objects. Qualitative researchers study people in their natural settings. This is so that they can identify how the experiences and behaviours of the people are shaped by the context of their lives, like the social, economic, cultural, or physical context in which they live.

Qualitative research can be distinguished from quantitative research methodology in several ways based on the characteristics that are inherent in the design of a qualitative study. Below are some of the articulated assumptions by researchers regarding the characteristics of the approach (Creswell, 2009). Some of these characteristics are used to position what this research is about to justify the use of qualitative methods.

Qualitative research takes place in natural settings (Creswell, 2009). Here, data is collected by the researchers in the field where the problem in question is being experienced. The problem in question regarding this research is health and safety issues in the Nigerian Construction Industry in particular, accidents and their root causes. An alarming phenomenon, which is socially determined and occurred mostly because of human error. Therefore to understand reasons for these accidents with a view to understanding their root causes and how these root causes could be mitigated, it is important the researcher have personal contacts with those involved in construction work in their naturalistic social settings (construction sites) through semi-structured interview and non-participant observation to have an in-depth understanding



of their work process. This is because factors that trigger these accidents are present in the work locations, and being in the natural work settings of participants gives the researcher the opportunity to see the work situations of these workers with respect to health and safety performance within the sites and to dive deep into different areas of discussions regarding the issue of discuss.

The quantitative method would not afford the researcher this opportunity as he can only elicit data through structured questionnaires, which only captures objectively pre-determined set out questions and gives no room for wider coverage of issues. In case of ambiguity of questions, many times the researcher is not there to explain these questions and as such lead to respondents either not responding to such questions or choosing the wrong answers, which can affect the result of the study in a negative way.

The primary instrument of data collection in qualitative research is the researcher (Matthews & Ross, 2010). Because of the sensitivity of health and safety issues and the goal of this research, it is important that the researcher is present in the natural settings where the accident phenomenon is being examined. This is so that he can personally identify issues from the perspective of his participants and elicit in-depth information from them that can help provide meaningful data to answer the research question and set out objectives of this study. This can only be achieved through using a qualitative study. The quantitative method would not afford the researcher this opportunity because its primary instrument of data collection is the questionnaire, which can be posted to respondent, emailed or hand delivered to respondent to fill and send back to the researcher.

Qualitative researchers collect data themselves by means of interviewing participants, observation of behaviours of participants or examining documents (Hennink, et al., 2010). Because this research required having in-depth knowledge of the health and safety issues in the Nigerian construction industry regarding accidents and its root causes, it was important to have a one on one interaction with construction workers to know and understand more about this phenomenon. The use of qualitative method afforded the researcher the opportunity to discuss this phenomenon with construction workers in Nigeria who are knowledgeable about this. The end goal of this research is to develop a lean health and safety framework for organizations to use for accident prevention on site. As already stated in chapter 1 of this work, lean maturity in Nigeria is low and as such many have not heard or know about lean. The use of qualitative method provided an avenue for the researcher to personally introduce and discuss the various

lean tools with participants thereby paving the way for participants to be asked questions based on these tools, and their knowledge about health and safety, through a semi-structured interview process and using non-participant observation method to observe the construction work environment, the workers as they carry out their task, and their behaviour towards safety. For example, where workers wearing their personal protective equipment's, and so on. Even though the method also allows the use of document analysis, this could not be used for the study because organisations refused to grant the researcher access to their health and safety documents because of the serious nature of health and safety. However, for the above reasons, the researcher makes use of the qualitative research approach. The next section discusses the reasoning behind this piece of research: inductive reasoning and highlights how the inductive reasoning relates to this thesis.

### **3.3. Inductive Reasoning**

Two broad methods of reasoning: deductive and inductive reasonings, are often referred to in research by authors (Sayer, 1992; Burney & Saleem, 2008; Zikmund et al., 2013; Hair, 2015). Deductive reasoning involves the logical process applied in deriving a conclusion about a specific instance, based on a known general premise or something known to be true (Zikmund et al., 2013). In applying deductive process, the researcher goes from a more general statement to specific assertions (Burney & Saleem, 2008; Zikmund et al., 2013). Deductive reasoning is consistent with natural science, i.e., quantitative studies and positivism, and focus on testing of hypothesis (Collis & Hussey, 2015; Hair, 2015).

On the other hand, inductive reasoning is a type of thinking which involves identification of patterns in a data to arrive at conclusions or build theories (Hair, 2015). Researchers apply this approach when attempting to build theory or conceptual framework from the data they collect (Hair, 2015). The inductive process starts from specific observations to broader generalizations and theories. (Burney & Salem, 2008). Inductive reasoning is consistent with social research, i.e., qualitative studies, and when a researcher is connected to the interpretivist paradigm as this present researcher, the researcher takes an inductive approach (Collis & Hussey, 2015). Furthermore, qualitative research, inductive reasoning, and case study design has been established to be closely tied together (Eisenhardt, 1989).

This research as highlighted in section 3.1.1. and 3.1.2 takes the constructivist ontology philosophical standpoint and interpretivist epistemology philosophical standpoint and applies both the qualitative method and multiple case studies approach which are consistent with inductive studies for the purpose of building theory (Eisenhardt, 1989; Collis & Hussey, 2015). Further, the research question for this study, refined by literature review laid the initial foundation for this study to borrow the inductive reasoning approach. This further built with enhanced understanding, and exposure to the research context. The inductive approach was therefore applied to understand the health and safety phenomenon regarding accidents in the Nigerian construction industry, the lean tools that can help mitigate the health and safety phenomenon, and to develop theory by developing a lean safety framework that construction firms can apply in a safety system to mitigate accident root causes. The next section discusses the case study research design.

### **3.4. Case Study Research Design**

Case study represents a design of enquiry found in many fields, especially evaluation. It as an approach where one or few instances of a phenomena is studied in-depth (Given, 2008). The case study research deals with the study of a case or cases within a real-life contemporary context or settings. The case according to Yin (2013) may be a concrete entity, like an individual, a small group, an organization, or a partnership (Creswell & Poth, 2018). It may be a relationship, a community, a decision process, or specific project, at a less concrete level (Creswell & Poth, 2018). Creswell & Poth (2018) gave a very comprehensive definition by defining case study as a qualitative approach, in which a real-life, contemporary bounded system (a case) or multiple bounded system (cases) is explored by a researcher over time, through detailed, in-depth data collection involving multiple sources of information (interview, observation, audio-visual materials, documents and reports), and reports a case description and case themes. The central notion about using a case study is to be able to inductively develop theory and the theory according to Eisenhardt & Graebner (2007) is emergent in the sense that it can be found in and developed by recognizing patterns of relationships among constructs within and across cases and their underlying logical arguments. In cases studies, the unit of analysis may be a single case as in a within site study or multiple case in multisite study (Yin, 2003; Creswell & Poth, 2018). This makes it possible for each case to be considered as distinct experiments, which stand on their own as units for analysis and thus can lead to replication

logic, which is central to theory building from case studies (Eisenhardt & Graebner, 2007). Case studies leads to formulation of a comparative study. However, all cases must be explored in detail and in great depth and the subject of a case may be a person, an organisation, a situation, or a country (Matthew & Ross, 2010). Because the case studies approach is a theory building approach that is embedded deeply in rich empirical data, building theory from cases is according to Eisenhardt & Graebner (2007) likely to produce theory that is accurate, interesting, and testable.

### **3.4.1. A Multi-Case Study**

Three types of case studies exist, Creswell & Poth (2018) states these to include the single instrumental case study, the collective multiple case study, and the intrinsic case study. While the focus of this research is channelled towards the health and safety issues in the Nigerian construction industry, particularly accidents and their root causes, there however exist three different classes of construction companies operating in the Nigerian construction industry (the small-scale indigenous construction companies, medium-scale indigenous construction companies, and multinational construction companies). This research is focusing on two, the small-scale indigenous construction companies and medium scale indigenous construction companies. To do a single case-study design would not afford the researcher the opportunity to investigate this issue widely within these two classes of construction companies in the country. Only a multi-case study design would give that opportunity to investigate at the small-scale and medium-scale level, which this study is concerned with. The single case study therefore will not fit the purpose of this study.

In the multiple case study, the focus of the researcher is also channelled towards one issue, but this time, the researcher uses multiple cases to illustrate this issue. In this study, the health and safety issue in question will be investigated in two of the three classes of construction companies in Nigeria. At the small-scale level, three construction companies will be investigated, at the medium-scale level, three companies will be investigated. Since this include cases from two different levels, the multi-case study design would fit this research. Although each company might be the subject of an individual case-study, however, the study as whole covers several construction companies and so using a multi-case study design would best suit this study (Yin, 2013). Using this design will make it possible to show different perspective

about accidents and their root causes in the Nigerian Construction Industry, which will in turn bring more robustness to this study (Yin, 2013). Multi-Case Study design leads to replication logic in which case the researcher replicates the procedures for each case thus leading to theory building (Eisenhardt & Graebner, 2007; Yin, 2003; Creswell & Poth, 2018). Broadly speaking, research dealing with theory building using cases according to Eisenhardt & Graebner (2007) typically answers research questions that address “how” and “why” very well in unexplored research areas. Lean and health and safety in construction in Nigeria research literature is new and unexplored and as such this strategy would help address the research question asked in this research very well.

The multiple case study approach was therefore chosen as a vehicle to bring to the open the health and safety issues regarding accidents and their root causes in small and medium scale construction companies in Nigeria chosen as cases for this study, and how the adoption of lean practices can be the foundation for a safety system to mitigate these root causes. This design would therefore help to look in-depth at the six cases chosen for this research primarily through semi-structured interview, backed with non-participant observation of workers in the cases (companies) in their natural settings to see first-hand, the health and safety issues they face while carrying out their various tasks on site and to introduce lean principles and tools to be used for the development of the lean health and safety framework to them. The design would also give the researcher the ability to look at the different cases as units on their own, compare these cases to look for similarities, dissimilarities and patterns within, which can lead to replication logic leading to inductive theory building (Eisenhardt & Graebner, 2007; Yin, 2003; Creswell & Poth, 2018). One of the challenges of using a case study deals with not being able to generalize. Several authors have commented on this (Eisenhardt & Graebner (2007; Yin, 2013). The position is that the purpose of case-studies research is about developing theory and not testing theory (Eisenhardt & Graebner, 2007). Thus, using multiple case study approach helps to gather representative cases so that generalizations can be made to theory (Eisenhardt & Graebner, 2007; Yin, 2013).

### **3.4.2. Unit of Analysis**

Unit of analysis according to Bhattacharjee (2012) refers to the person, collective, or object, that is the target of the investigation. Yin (2013) stated that in defining the case to be studied, two different steps need to be considered: defining the case and bounding the case.

The case: the research investigates health and safety issues in the Nigerian construction industry; specifically, accidents and their root causes, with an end goal of creating a lean health and safety framework to help eliminate or reduce as much as possible these accidents. This investigation includes understanding why and how these accidents happen, so that the root causes can be eliminated. To achieve this, it is important to get first-hand information from actors in the construction industry. There are three levels of construction companies in the country. These are small scale indigenous construction companies, medium scale indigenous construction companies, and multinational construction companies. However, the focus of the research is on the small-scale and medium scale companies. Therefore, they are the cases and unit of analysis for this research. These are companies owned by Nigerians and operate locally on building construction projects in the country.

Bounding the case: the actors in the Nigerian construction industry are the different level of construction companies carrying out construction works in the country: of the three levels, the small-scale and the medium scale indigenous construction companies are being interviewed for this study. Representatives from these companies were interviewed and observed for the purpose of collecting qualitative data for this study. Although those interviewed were workers from the companies, the unit of analysis are the construction companies themselves and these workers are representatives of the companies that operates in the industry.

### **3.5. Interview Method**

According to Yin (2013), the interview happens to be one of the most important sources of case-study evidence commonly found in case study research.

Interview is a data collection method, which usually facilitates direct communication between two people, through face to face communication, or at a distance through telephone calls or over the internet, and which enables the interviewer to elicit information, feelings, and opinions from the person being interviewed termed the interviewee by use of questions and interactive

dialogue (Matthews & Ross, 2010). The interview is usually controlled by a person who ask questions of another person. Usually, people use interviews when trying to find out more about certain things by asking questions in a wide range of contexts about what people feel, think or experience in the case of a researcher.

There are three types of interviews. They include structured, semi-structured, and unstructured interviews.

Structured interviews according to Denzin & Lincoln (2000) involve a situation where respondents are asked the same sets of pre-established questions by the interviewer with a limited sets of response categories. In this type of interview, the room for variation in response is very little except in cases where open ended questions are used. Unstructured interview according to Given (2008) involve asking relatively open-ended questions off research participants to discover their perception on the topic being researched on. They are sometimes referred to as open interviews. In this type of interview method, the direction of the interview is always determined by the interviewee. Semi-structured interview refers to a qualitative data collection strategy, in which informants are asked a series of predetermined but open-ended questions by the researcher (Given, 2008).

### **3.5.1. Semi-structured Interview**

A semi structured interview according Lunghurst (2003) refers to a verbal exchange where one person, the interviewer attempts to get information from another person, the interviewee by asking questions. Although the interviewer prepares a list of predetermined questions, this kind of interview unfolds as conversations do, thereby offering participants the chance to explore issues they feel are important. This type of interview is made use of to collect data in a wide variety of research designs such as cross-sectional studies, longitudinal studies, ethnography, evaluation research and case studies, which is the research design being applied in this study. Mostly, the method is typically associated with the collection of qualitative social data when the interest of the researcher is on people's experiences, behaviours and understandings, including how and why they experience and understand the social world in this way (Matthews & Ross, 2010).

The researcher has chosen this method for the following reasons. Firstly because this form of interview is equipped to explore the perceptions and opinions of respondents regarding complex and sometimes sensitive issues, and they make it possible for the interviewer to be able to probe for more information and clarification of answers when issues that are important arises while the interview is going on (Barriball & While, 1994; Miles & Gilbert, 2005). This method gave the researcher the ability to understand the perceptions of participants regarding accidents and their root causes in their various organizations and through this method it was easy to probe deeper into more questions regarding safety in these organizations. Secondly because of its hybrid nature, it gave the researcher the ability to structure the interview into segments, which created the opportunity to move from fully open-ended questions to questions that are more theory driven while the interview is going on (Galletta, 2013). Thirdly, because of the nature of semi-structured interview as a versatile means by which data can be collected, it can be used to develop a much deeper understanding of the study research question through exploring contradictions within the accounts of participants (Miles & Gilbert, 2005). Fourthly, based on literature review on accidents and their root causes in construction, and lean thinking in construction, the phenomenon under study is known in parts, despite a more comprehensive framework is absent. Therefore, the use of semi-structured interview for example enabled the researcher to build on the existing knowledge and probe deeper into the underlying causes of accidents in the Nigerian construction industry by asking questions about what is unknown so that more knowledge can be acquired regarding this phenomenon. This helped in building the interview guide.

### **3.5.2. Pilot Interview**

As a means of testing the interview questions for the research to ensure the right questions are being asked, a pilot interview was conducted with a few colleagues. Through this interview, some issues were uncovered which helped re-structure and improve the main interview questions used for the study. For example, through the pilot interview, the researcher was able to understand that asking the question: “what are the root causes of accident?” can be considered as: “what are the causes of accidents?” by participants. However, causes and root causes are two different things as one speaks of direct cause and the other goes beyond direct cause and probe deeper to the root. Therefore, it was deemed necessary that to get the right response and answer to the question, the difference between causes and root causes must be



explained to participants before the question on root causes are asked. It was further decided through this that participants should be asked what they think the reasons for accidents are. This gives participants the ability to explain the causes more and gave opportunity to further probe participants. Hence in the main interview questions, participants were asked questions on reasons for accidents, and root causes using. Furthermore, the pilot provided an opportunity to structure the questions in the right way without using technicality of language. This made the questions easy to understand for participants.

### **3.5.3. Interview Guide**

An interview guide is designed to help a researcher to conduct semi-structured interview (Matthews & Ross, 2010). The guide helps the researcher to remember the points to cover, it helps suggest ways of approaching each topic, it contains an introduction and a way of ending the interview, it helps to ensure that all topics are covered by the interviewer, it help give a possible order of topics and helps the interviewer to enable people to talk as fully as possible in their own way (Matthews & Ross, 2010). It must be stated that the guide is not just a list of questions that need walking through by the interviewer as is the case of a questionnaire. Rather, it acts as an agenda for the interview to aid the researcher in getting answers to her questions (Matthews & Ross, 2010). Bryman (2013) suggested some best practice guidelines with regarding designing interviews. The interview for this research, which was a semi-structured interview were designed based on these standard best practice guidelines aided by the conceptual framework developed for this research. See figure 1. The conceptual framework made it possible to outline the keys questions used to develop various sections in the interview guide for the study because it helped to organise the ideas and to dig out the questions needed to provide answers to the various objectives developed to answer the research question. Furthermore, the conceptual framework made it possible to understand what was needed from participants in terms of data, which informed how the questions were asked.

The questions are in three sections with some sections having sub-sections as explained below.

**Section 1** seeks information about the participants and their organisations profile. In this section, participants interviewed were asked to introduce themselves, the number of years they have worked in construction with respect to work experience, the kinds of construction organisation they have worked with, the profile of their organisations, and their job titles.

**Section 2** focus on questions relating to accidents and causes, including root causes. In this section, questions focus on accidents in the Nigerian Construction Industry, types of accidents and root causes of accidents, accident investigations, and management actions with respect to the actions they take or fail to take when accidents occur on site. This section helped to get answers from respondents regarding what the root causes of construction accidents are in the Nigerian construction industry.

**Section 3** focus on lean construction with reference to the lean tools being used for this research. To this extent, questions in this section focuses on the 5S methodology, Visual Management, and the A3/PDCA Problem Solving Framework. In this section videos records of the various lean tools were played to participants for them to understand and know what the tools are about before questions were asked.

### **3.6. Observation (Non-participant)**

This refers to the act of using the five senses by an observer to note a phenomenon in the field setting. It is often carried out with a note taking instrument and recording it for scientific purpose (Creswell & Poth, 2018). Things observed can include the participants themselves, their physical settings, their activities, their interactions, their conversations, including the behaviour of the observers themselves. There are four different observation types (Creswell & Poth, 2018). They include (1) Complete observation, in which the researcher is fully engaged with the people being observed. (2) Participant observation, in which the researcher partakes in the activities in the site. In this case the role of the participant is more noticeable than the researcher's role and as such helps the researcher to get insider views and subjective data. (3) Non-participant observation, in which the researcher is an outsider of the group being studied and watches and takes note from a distance. The researcher in this case can record his or her data without direct involvement with the activities or people. (4) Complete observer, in which the people being studied neither sees nor notice the researcher.

For this study, the researcher took the non-participant observer position for several reasons. (1) this position gave the researcher the ability to observe the surrounding environment of every company site visited whether they were safe to work in, including the workers, whether they make use of personal protective equipment's and their attitudes and behaviour towards work, without being distracted by being integrated into the activities of the workers. (2) When an

observer actively becomes a part of an activity, the possibility is that there will be some wrong things being done by the group. By being active the observer will not be able to analyse the situation with neutrality. However, the non-participant observer position gives the researcher the ability to be detached from the group and thus give an unbiased view. (3) Taking this position gives the researcher the ability to play an impartial role, which comes with the merit of giving the researcher a special status thus every participant co-operates with the study.

### **3.7. Theoretical Sampling**

A sample according to Kothari (2004) is the fairly selected respondents from the total population of a study and the process of this selection is called the sampling method. There are two major categories of sampling techniques depending on the population size of the study. These are probability sampling techniques and non-probability sampling techniques. Theoretical sampling, which is a variation of purposive sampling technique is a non-probability sampling technique that is associated with small in-depth studies with research designs that are centred on gathering of qualitative data focused on generating theory. This method is most suitable for case study research because case studies focus on developing theories rather testing theories (Graebner, 2007). Theoretical sampling was described by Glaser & Strauss (2017) as *“a process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges”*

This sampling method does not involve any attempt to creating sample that are statistical representations of a population. Rather, the technique focuses on choosing people or cases with purpose so that the researcher can explore his or her research questions or develop a theory (Matthews & Ross, 2010). In simple terms, it is a technique that rely on the researcher’s judgment regarding selection of the units that are to be studied. With theoretical sampling, cases are selected because they are particularly suitable for revealing and extending relationships and logic among constructs (Graebner, 2007). The approach also allows the researcher to study the research topic in-depth, in this case health and safety in the Nigerian construction industry. Using this technique will make it possible to reveal unusual phenomenon about the issue, replicate findings from other cases in this study, eliminate alternative

explanations, including elaboration of the emergent theory. In this way, the theory can be better grounded, more accurate, and more generalizable (Graebner, 2007).

This research focuses on improving health and safety in the Nigerian construction industry. Based on this, organisations involved in construction practice in Nigeria would be more familiar with the health and safety issues facing the industry. Therefore, the best sample to make use of for this enquiry are construction organisations undertaking construction business in Nigeria. However, because of the large nature of the construction industry in Nigeria and the small nature of this research, it would be impossible to collect data from all construction organisations in the country. Therefore, it is important that samples be taken from the larger population of construction organisations as representative samples, and participants from such sample must be participants that have real knowledge of construction process in Nigeria and as such can contribute appropriate and meaningful data in aiding the success of this research. Having looked at the various sampling techniques available, the sampling techniques that best suit this research are the theoretical sampling technique and some element of the snowball non-probability sampling technique.

This technique was chosen for several reasons. (1) researchers choose multiple cases because of theoretical reasons like replication, extension of theory, contrary replication, and including elimination of alternative explanations. Since this is a multi-case study research, using this technique will make it possible to reveal unusual phenomenon about the issue as illustrated in the paragraph above, replicate findings from other cases in this study, eliminate alternative explanations, including elaboration of the emergent theory. In this way, the theory can be better grounded, more accurate and more generalizable (Graebner, 2007). (2) It is a technique that is generally associated with small in-depth studies that is centred on gathering of qualitative data, generating theory and it relies on the judgement of the researcher in selecting the choice of informant based on the qualities they possess (Graebner, 2007; Tongco, 2007; Matthews & Ross, 2010). The technique also provides the researcher the ability to set out to find out people with knowledge and experience in the field of enquiry who are willing to provide the needed information the researcher needs.

Having used this technique in identifying organisations that can provide meaningful data to this research, it was however a problem getting access to these organisations. The researcher sent emails to some identified construction organisations in Nigeria from the United Kingdom but received no response. Upon flying down to Nigeria, the researcher made personal contact

to these organisations. Getting them interested was difficult because of the sensitive nature of health and safety issues. Companies refuse to grant access. However, through personal contact the researcher was able to get contact with the first two companies interested in participating. Through employing some element of the snowballing technique, the researcher was able to expand participation to other organisations by asking participants from these companies to refer him to other organisations that are interested and willing to participate in the research. Snowball sampling starts with the researcher identifying a few people known to be the type of people the researcher wants to be involved in the research, contact is made with such people and then through meeting with these people, the researcher asks for suggestions from them regarding people with similar characteristics, who are then contacted by the researcher, and so on. Overall, six construction organisations participated spanning small-scale indigenous construction companies, and medium scale indigenous construction companies. A total of twenty-seven interviews were conducted with personnel from these organisations. Personnel's interviewed included project managers, project safety managers/officers, project supervisor, and labour workers. These are specified in the table below along with the number of interviews conducted with each of these companies and the job titles of the personnel's interviewed.

*Table 4 Interview Details*

<b>Company Type</b>	<b>Number of Interviews</b>	<b>Personnel's Interviewed</b>
Small Scale Indigenous Company 1	5	1 Project Manager, 1 Project Supervisor, 3 Labour Staffs.
Small Scale Indigenous Company 2	5	1 Project Manager, 4 Labour Staffs
Small Scale Indigenous Company 3	2	1 Project Manager, 1 Safety Officer
Medium Scale Indigenous Company 1	5	1 Project Manager, 1 Safety Officer, 3 Labour Staffs
Medium Scale Indigenous Company 2	5	1 Project Manager, 1 Safety Officer, 3 Labour Staffs
Medium Scale Indigenous Company 3 (Road Construction)	5	1 Project Supervisor, 4 Labour Staffs

### **3.8. Data Collection Process**

Data is defined by Matthews & Ross (2010) as a collection of facts or other information like opinions or values, which can be analysed and from which conclusions can be drawn. Data can come in the form of spoken or written words, it can be non-verbal in the case of pictures, gestures, or sounds, which can be expressed as words, it can be structured in different ways, it can be constructed or produced by individuals or groups, it can be made up of factual and value statements, it can include things said by people (content), and the language used in expressing the content, and also can include the thoughts and reflections of the researcher. After the formulation of research questions or hypothesis for a study or studies, researchers are expected to gather data with which they will use to address the research questions or hypothesis. Data collection is therefore according to Matthews & Ross (2010) a practical activity that must be conducted within time, spatial and time constraints, using a range of research tools. A research tool is simply the means, by which the data is collected, and this can be in the form of questionnaires, and in the case of interviews; structured, unstructured, or semi-structured. The researcher herself becomes the means by which the data is gathered.

The semi-structured interview and non-participant observation data for the research were collected in Nigeria with selected construction personnel from small and medium scale construction companies in the country. After approaching the companies and discussing the purpose of the research with them, permission was granted for the researcher to go on site and interview some of their staffs ranging from project managers to safety officers, site supervisors to labour workers. Upon getting to the various sites, the researcher was taken to the site office, which were quiet, noise free and free from disturbance. Each of the selected staffs were interviewed one after the other after giving each a copy of the participant informed consent form to read and sign before the start of each interview. Overall, 27 participants were interviewed ranging from project managers to labour workers as represented in table 4 below. The interviews were recorded using a voice recorder and phone voice memo, including notes taken as the interview proceeded. The interviews all had different timings with the highest timing lasting between an hour to an hour thirty-seven minutes and the lowest lasting between thirty minutes to an hour. The variation in timing is because some participants gave more information, which led to more probing (semi-structured interview quality); therefore, longer period was spent interviewing these. Those that went over an hour were mostly project managers and safety officers and supervisors.

The interviews were conducted both in English language with some of the participants, and in the Nigerian local Pidgin English with others. The reason for the use of local pidgin English for some of the interviews was because some of the participants interviewed cannot speak and understand proper English language. As such, the researcher had to ask them the questions in local pidgin English, and their responses were in local pidgin English language as well. Each interview was personally transcribed verbatim by the researcher and the interviews conducted in local pidgin English language were converted to proper English language during transcribing by the researcher for coding. Where some spoken words were not clear, the recorded interviews were played back severally to capture every bit of information as spoken by respondents.

To collect the data, the researcher purchased a digital voice recorder specifically for this purpose and went with the voice recorder, a phone voice memo recorder, all fully charged and a note pad. The digital voice recorder and phone voice memo recorder were turned on with permission to record given by participants before the interview started. After the interviews, the data was transferred from the voice recorder as files to the personal computer of the researcher, which is password protected. The data were then stored on the researcher’s university personal storage account, his personal google drive account, and copies sent to his university personal email account. All these accounts are all password protected to protect the data and to abide to the data protection act. To manage and organize the recorded interviews, all interviews were recorded company by company and each company was given a unique identifier code with interviews for each company stored under these codes to avoid mixing data between companies.

The table below represents the sample characteristics for all interviews conducted.

*Table 5 interview sample characteristics*

Company	Participant Code	Position	Working Experience (Years).	Company Type Classification	Location
<b>SSIC 1</b>				<b>Small</b>	<b>Lagos State. Nig.</b>
	A1	Project Manager	14		
	A2	Project Supervisor	7		
	A3	Carpenter	12		
	A4	Mason	8		
	A5	Electrician	8		

<b>SSIC 2</b>					<b>Lagos State Nig.</b>
	B1	Project Manager	11		
	B2	Electrician	14		
	B3	Carpenter	12		
	B4	Bricklayer	15		
	B5	Helper	5		
<b>SSIC 3</b>					<b>Lagos State. Nig.</b>
	C1	Project Manager	12		
	C2	Safety Officer	10		
<b>MSIC 1</b>				<b>Medium</b>	<b>Delta State. Nig.</b>
	DI	Project Manager	15		
	D2	Safety officer	8		
	D3	Mason	10		
	D4	Electrician	10		
<b>MSIC 2</b>					<b>Delta State. Nig.</b>
	E1	Project Manager	10		
	E2	Safety Officer	12		
	E3	Carpenter	9		
	E4	Mason	15		
	E5	Welder	8		
<b>MSIC 3</b>					<b>Edo State. Nig.</b>
	F1	Project Supervisor	18		
	F2	Labour 1	11		
	F3	Labour 2	8		
	F4	Labour 3	8		
	F5	Labour 4	6		

### 3.9. Thematic Analysis

In the analysis of qualitative data, several methods are available. Normally, data analysis takes place during research process after the data for the study has been collected. Matthews & Ross (2010) defines analysis as a process of working with the data to describe, discuss, interpret, evaluate, and explain the data in terms of research questions or hypothesis of the research project. Going forward, Matthews & Ross (2010) the defines data analysis as the collection of methods that researchers can apply to the data they have collected, to describe, interpret, explain, and evaluate the data. To achieve what these definitions suggests, the data analysis process would usually involve the researcher organizing the data, carrying out a preliminary read through of the data, coding the data and organizing themes, representing the data, and



forming an interpretation of the data (Creswell & Poth, 2018). However, the analysis process is not fixed as different researchers have different ways of analysing their qualitative data based on the type of study.

In case study analysis, the process includes the researcher making a detailed description of the case and its settings. Several techniques are available for helping with the process of analysing qualitative data. Matthews & Ross (2010) stated some of these techniques to include thematic analysis, content analysis, discourse analysis, grounded theory, and analysing narratives. Matthews & Ross (2010) and Creswell & Poth (2018) also stated the research strategies these techniques of analysis can be applied in: interview data can be analysed using thematic analysis or grounded theory; observations data can be analysed using content analysis, thematic analysis, and grounded theory; document data can be analysed using content analysis, thematic analysis, and discourse analysis; narrative data can be analysed using narrative analysis, focus group can be analysed using thematic analysis, content analysis, and discourse analysis; vignettes can be analysed using thematic analysis, and discourse analysis.

For this study, data was collected through semi-structured interview. Therefore, in line with the suggestion by Matthews & Ross (2010) and Creswell & Poth (2018) about the analysis technique that should be applied for case-study strategy, which is the strategy for this research, the researcher will make use of thematic analysis as the analysis technique for this study. The decision to use thematic analysis is based on several of the following reasons. (1) It is a flexible approach that provides rich and detailed, yet complex account of data through its theoretical freedom (not connected to any theoretical framework) (Braun & Clark, 2006). (2) The

It helps the researcher to identify, analyse, and report patterns within data, helping to organise and describe the data set in rich detail thereby making it a useful method that can made use of in examining the viewpoints of different research participants, highlighting similarities and differences and generating unanticipated insights (Braun & Clark, 2006; Nowell et al., 2017); it can be made use of to summarize key features of a large data because it forces the researcher into taking a structured approach to data handling thereby helping in producing a clear and organized final report (Nowell et al., 2017).

Braun & Clark (2006) defined thematic analysis as a method of identifying, analysing, and reporting patterns (themes) within data set. Matthews & Ross (2010) defined thematic analysis as a process of working with raw data to identify and interpret key ideas or themes. This process

according to Matthews & Ross (2010) is achieved by working with and remaining in-touch with the raw data throughout. Given (2008) defined thematic analysis as a data reduction and analysis strategy, by which qualitative data are segmented, categorized, summarized, and reconstructed in a way that captures the important concepts within the data set.

To segment these key themes in the data set, coding is made use of. Coding represents one of the significant steps a researcher takes during analysis to organize and make sense of textual data and involves subdividing the data and assigning categories (Basit, 2003). Codes are words or short phrases that uses symbols to assign summative, salient, essence-capturing, and or evocative attribute for a portion of language-based or visual data like interview transcripts, participant observation field notes, documents, journals, emails, internet sites, literature, photographs and so on (Saldana, 2013). Coding makes it possible for the researcher to communicate and connect with the data to aid comprehension of the emerging phenomena and to generate theory grounded in data (Basit, 2003). Coding can be done manually and or electronically using computer aided software like Nvivo, Excel, Atlas.ti, and so on (Basit, 2003; Saldana, 2013, Yin, 2013).

Given (2008) defines thematic coding as the strategy, by which data are segmented and categorized for thematic analysis. It is a process of generating ideas and concepts from raw data like interview transcripts, reports, fieldnotes, newspaper articles, etc (Given, 2008). Coding facilitate the development of themes and vice versa (Given, 2008). For this research, the data was coded thematically using the Nvivo computer software after the researcher had first familiarized himself with the data. Initial codes were then set up to facilitate the development of themes, final themes and sub themes were then created, which will be made use of for the analysis stage of this research.

### **3.10. Data Analysis**

Semi-structured interviews were used to collect qualitative data for this research. The interviews were recorded using voice recorder, phone voice memo and notes were also taken while the interview was going on. The interviews were transcribed personally by the researcher and analysed using thematic analytic process, which has been explained in section 3.9.

To systematically organise, manage and analyse the data, the researcher made use of a computer assisted qualitative data analysis software NVivo. NVivo is a software program that is made use in both qualitative and mixed method research for the analysis of unstructured text, video, audio, image data, interviews, focus groups, surveys, journal articles and so on.

Braun & Clarke (2006), gave phases of analysis outline in their study on thematic analysis. Based on this, the interview for this study was analysed using this guide as stated below:

**Familiarize yourself with the data:** The data for this study was collected via semi-structured interviews by the researcher himself. The researcher read through the whole data set to familiarize with the data and to search for issues of interest such as relationships and patterns. While doing this, notes were taken by the researcher. According to Braun and Clarke (2006), transcribing of data into written form, even though a time consuming and frustrating process is an excellent way for familiarising with one's data. For this research, the interview data was transcribed verbatim, taking note also of non-verbal utterances. Recorded interviews were played back severally where the spoken words are not clear to capture every bit of information as respondents placed them. The transcribing process was another way the researcher was able to become familiar with the data in its true nature. The data was then imported into the NVivo package.

**Generating the initial codes:** The process of importing the data resulted to creating initial codes also referred to as nodes in NVivo as each transcript is imported into the software. These codes facilitated the development of themes.

**Searching for themes:** After generation of the initial codes by the researcher, the codes were then sorted and grouped under different themes from words and phrases derived from the interview transcripts. Sub themes were also created.

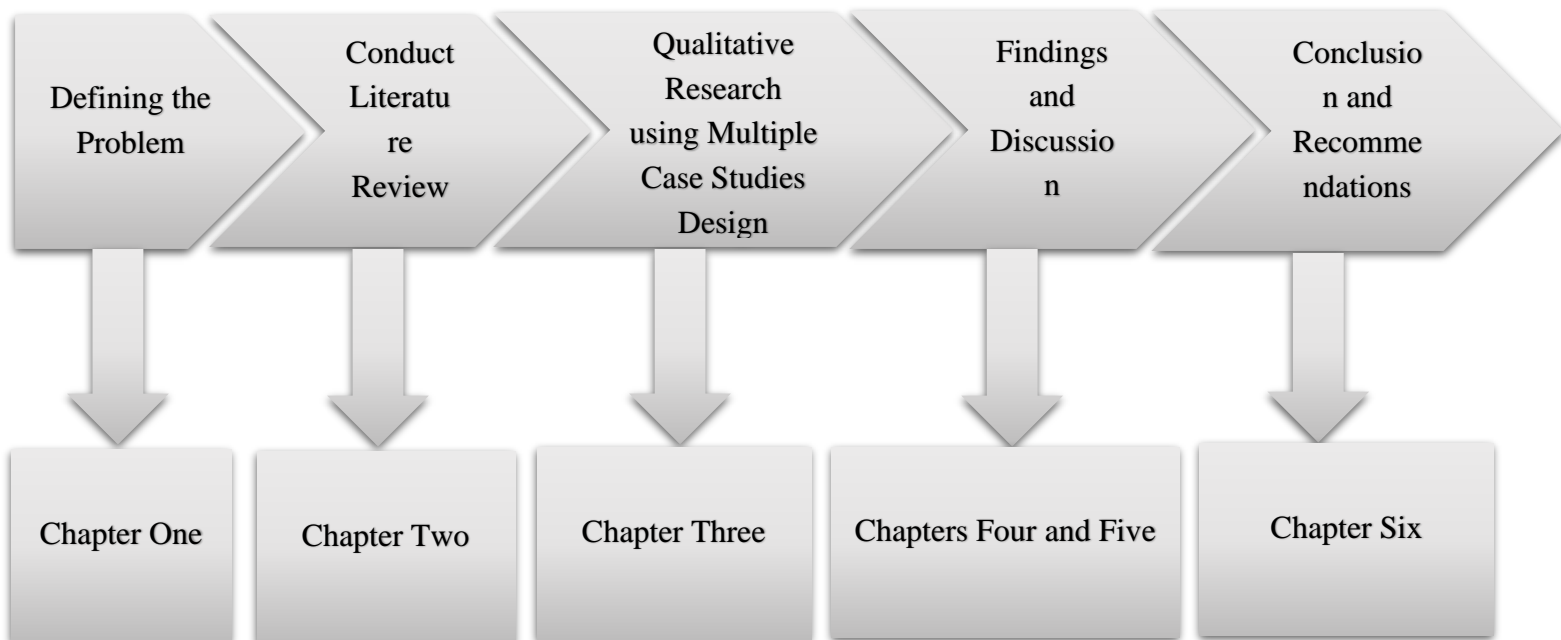
**Review of themes:** Haven created the themes and sub-themes from the interview transcripts, the created themes were then reviewed. In doing this, the researcher eliminated some themes and sub-themes that were not relevant and merged some.

**Defining and Renaming themes:** Each theme was investigated more appropriately to be able to understand more what the themes are about and the aspect of data the themes capture and the relationships the themes have within themselves.

**Producing the report:** The findings that were produced from the various themes were analysed from the original data. This will be used along with findings from the literature review as the discussion synthesis to provide a write-up that is concise, logical, coherent, and valid, that answers the research questions for this study and contribute to knowledge.

### 3.11. Research Process

Figure 6 below shows the research process for this study through a flow chart. The research started with first defining the problem statement for the study leading to the formulation of a research aim, question, and objectives. Having defined this, the researcher further went on to conduct a comprehensive literature on the phenomenon under investigation, Multiple Case Studies design was applied to investigate the phenomenon in three small scale and three medium scale indigenous construction companies in Nigeria. Semi-structured interviews and non-participant observations was used to gather data. Chapters four, five and six focuses on the findings, discussions, conclusions, and recommendations of the study.



*Figure 6 Research Process Flow Chart*

### **3.12. Reliability and Validity**

To ensure rigour and robustness is met in this research, the researcher took into consideration all quality checks. These include reliability, which refers to whether or not the same answer is derived when an instrument is used to measure something more than once (Bernard, 2000); Validity, which refers to the accuracy and trustworthiness of instruments, data, and findings in research (Bernard, 2000); Generalization, which deals with the question of how far a researcher is able to claim that the results of findings from his or her research are true for or relevant to the wider population or a different context (Matthews & Ross, 2010); and ethics, which refers to the moral deliberations, choices and accountability on the part of researchers throughout the process of the conduct of the research (Miller et al., 2012).

To ensure reliability, all recorded interview and non-participant observation data for the research were well stored and safely secured. All interviews were transcribed personally by the researcher listening carefully to every bit of recording and playing recordings repeatedly in cases where what is said is not clear to ensure the right information is transcribed as they have been relayed. Also, all coding done on the transcribed data were crosschecked in a careful manner to ensure that the codes generated rightfully define the themes, words and phrases used. The transcripts were repeatedly read through to ensure that mistakes are eliminated, as such transcribed data are accurate. The process used in achieving this is very transparent and the data are available if needed (Matthews & Ross, 2010). There are things that can bring bias to the findings, which ought to be eliminated so that the results are reliable. The researcher took this into consideration. Therefore, to eliminate things like participant bias in the study all participants were interviewed one-on-one on each site visited in rooms where it was just the researcher and the participant. Doing this was important because the presence of others around could make participant not to want to give out the right information because of fear of being overheard by others thereby putting the participant in trouble. This could lead to false data being given by participants and could negatively affect the outcome of the research. Hence the one-on-one in a quiet room interviews with participants. Also, participants were well granted permission by their managers to take their time during the interview, so there was no rush, which could lead to low quality information. From the side of the researcher, two to three interviews were conducted per day, and sometimes one per day all through the duration of the twenty-seven interviews. This was important because conducting more than four interviews

per day can be tiring and when such tiredness comes in, the researcher may end up not asking the questions the way he should leading to errors in data collected.

The concept about the test of validity for research mainly deals with the questions of whether the researcher is researching what he/she thinks he/she is researching, and whether the data he/she is gathering is relevant to the research question (Matthews & Ross, 2010). With respect to case-study research, Yin (2013) stated the tactics for validity by looking at four different validity levels: construct validity; internal validity; external validity; and reliability.

For this research, with respect to construct validity, Yin (2013) suggest the availability of three different tactics to improve construct validity: use of multiple sources of evidence; establish chain of evidence; and have key informants review draft case study report. Any of these three strategies can be made use of. The plan in this research is to improve health and safety in the Nigerian construction industry by focusing on accident and their root causes and providing a lean health and safety framework for organisations to make use of to improve safety performance. To ensure construct validity in this research, semi-structured interview was made use of as the main source of evidence in the data collection, backed up by non-participant observation across the six cases. Semi-structured interview was made use of primarily because the researcher already had some knowledge of the phenomenon under investigation, though not complete through already established theories. Semi-structured interview by nature are used when we already know something about the phenomena, because of this, we know what to ask based on that, which we already know. These interviews and non-participant observation across cases can help with triangulation and ensure that there were convergent lines of enquiry (Yin, 2013). The sources of evidence for this research therefore include the interviews, literature from various sources, and notes taken during interviews including non-participant observation of participants in their work environments. Other chains of evidence like documents from the companies interviewed could not be assessed because of the sensitive nature of health and safety. Companies were not okay with the idea of these documents being examined, perhaps because even though some of them may have these documents, which stand as evidence of their being health and safety compliant, in actual sense many of them however do not practice any form of safety. Therefore, giving out these documents could land them in trouble of possible prosecutions. Moreover, many do not keep accidents records, so they have no documents to produce in relation to this. With the chain of evidence for this study, others conducting this same study can be expected to produce the same results.

With respect to ensuring internal validity for this research, during the data analysis stage of the research, data source triangulation by way of cross-case analysis will be performed to look for similarities and differences. Therefore, as a way of achieving this, interview, and non-participant observation data from the six cases in this study were cross analysed to look for similarities and differences. This helped to increase internal validity for the study (Baškarada, 2014). To ensure external validity for this study, replication logic was made use of. This is because replication may be made if two or more cases are shown to support the same theory (Yin, 2009). Thus, in this study, findings from the six cases will be generalized to theoretical propositions because the purpose of this study is to generalize to theory rather than to generalize to populations or universe (Eisenhardt & Graebner, 2007; Baškarada, 2014).

### **3.13. Methodological Limitation**

As with every study, there are limitations. This study has some methodological limitations which are discussed below.

#### **3.13.1. Sample Size**

The initial plan of the researcher regarding sample size was to conduct thirty-six interviews across six case study companies. Three from the management levels of each organisation ranging from project managers, project supervisors, and safety officers. Three from the labour levels of each organisation ranging labour construction workers with different roles. However, upon getting to Nigeria to collect data for the research, it was discovered majority of the small-scale indigenous firms in the industry did not have individual management workers across the three management roles chosen for the research. For example, in some of the companies, i.e., small-scale company 2, the project manager also functioned as project supervisor. Some companies including medium scale companies only gave access to the researcher to interview certain number of staffs. In small scale company three for example, the researcher was only allowed to interview two management staff and no labour. Having the thirty-six pre-planned number of interviews would have brought more robustness to the study. However, the twenty-seven interviews conducted across all levels for the study met the data saturation goal.

### **3.13.2. Access to available data**

The researcher would have loved to make use of more than the two sources of evidence applied in this research. The plan was to make use of semi-structured interview, non-participant observation and document analysis. However, the companies that agreed to take part in the research refused to allow the researcher access to their health and safety documents. This was due to the sensitive nature of health and safety. A lot of these companies do not follow safety rules and as such fear allowing access to these documents for fear of getting in trouble or facing possible prosecution. Having access to these documents would have brought a lot more robustness to the study. Future studies can make the study more robust by using company health and safety document as part of the sources of evidence.

### **3.14. Ethical Consideration**

Ethics deals with the morality of human conduct, and refers to the moral deliberations, choices, and accountability on the part of researchers throughout the process of the conduct of the research (Miller et al., 2012). Silverman (2010) talked about the three questions most frequently raised in research ethical guidelines. They include codes and consent, confidentiality, and trust.

Codes and consents deal with informed consent, which means that in a research, participants in the research have the right to know that they are being researched. They have the right to be informed about the research nature, and, the right to withdraw from the research at any time. To achieve this, it is important and mandatory that researchers provide participants 'informed consent form' to sign. Confidentiality deals with the subject that researchers should protect the identity of research participants, the places, and locations the research was conducted in. Regarding this, different countries have different guideline and different organisations have different guidelines, with which confidentiality issue is treated.

Trust deals with the relationship between researchers and participants and extends to the responsibility the researcher has, to not according to Silverman (2010) spoil the field for others in the sense that potential research subjects refuse or get reluctant about being studied.

Regarding this research, all issues stated above with respect to codes and consent, confidentiality, and trust were duly considered. As is the procedure in the University of



Huddersfield, all ethical forms dealing with the above issues regarding this research were filled out in the University ethics forms, signed, and submitted to the University of Huddersfield Ethics Committee. The University Ethics Committee looked through these forms, decided that they are satisfied with how these issues will be dealt with by the researcher. Based on this, the researcher was given the approval by the Ethics Committee to go for the data collection.

During the data collection, participants were duly informed about the purpose of the research and of their rights to withdraw at any time should they feel not comfortable to participate further. They were given consent forms to this effect and they all signed. Participants were also informed that their confidentiality will be protected and that regarding their personal information, pseudonyms will be made use of instead of their original information. They were also informed that all data collected from them for this research will be destroyed at the end of the research. All these are in conformity with research ethical guidelines.

### **3.15. Chapter Summary**

This chapter has presented the methodology applied to achieve the objectives of this research. The chapter started by discussing the research context for the study, which is Nigeria and provided a justification on why the research is being conducted in Nigeria. Following this, the chapter discussed the research philosophy and justifications were given for choosing the constructivism and interpretivist positions, respectively. The qualitative research approach was then discussed as the methodological choice for the study with reasons for this choice also outlined. Then the chapter discussed the case study design, with justifications on the reasons for using the multiple case study design including the unit of analysis. Furthermore, the chapter discussed the tools and techniques used to gather the data, as well as how the quality of the data was preserved by the researcher. This also includes the analysis technique used to analyse the qualitative data for the study. The chapter ended by discussing the reliability and validity of the research, and the issues relating to research ethics were acknowledged. Having discussed the methodology chosen for the study. The next chapter will present the findings from the study.

## 4. Chapter Four – Findings

Previous chapter has established the menace of construction accidents in Nigeria. Therefore, this research aims at answering the research question: “how can the adoption of lean practices can be applied in a safety system to mitigate accident root causes in the Nigerian Construction Industry”. Based on this question, the conceptual framework in figure 1, which depicts the theoretical underpinnings of this research was developed to explain this phenomenon following a synthesis of literature on sociotechnical systems theory, health and safety in the Nigerian construction industry, including the root causes of accidents as updated in figure 2 and lean construction. To this extent, the conceptual framework will play an important role in the analysis of the data in this chapter by helping to provide answers to the research question. Firstly, the underpinning theory suggest that to eliminate accident root causes, focus should be placed on the broader sociotechnical aspect of the environment surrounding the workers. Thus, we should look at both the social and technical elements of the work environments as depicted in the conceptual framework in figure 1. In this way, the conceptual framework directs the focus of the findings on the workers, and the organisations, who are the social elements of the work environment, the safety systems being used, which are the technical elements of the work environment and the construction sites, which are the sociotechnical work environment. Therefore, the findings here will be outlined and examined based on these elements in the six case study companies using themes developed during the coding stage of this research.

Relying on the above understanding, this chapter presents findings from the six case study companies interviewed and observed for this research. In these findings, interview data is the core of the data, where thematic analysis was made use of. However, where relevant, observation data has also been made use of to inform the process of analysis and interpretations of the findings. Therefore, the chapter will present findings relating to the accidents in the construction industry and their root causes from the case study companies. The chapter will also present findings about participants perceptions on the lean tools used for the study in relation to if these lean tools can help improve health and safety on site and as such prevent accidents from happening. Thus, the chapter will present these findings following the objectives 1 and 2 of this research, which again are:

1. Investigate the root causes of construction accidents in the Nigerian Construction Industry.

2. Explore how and to what extent lean tools such as the 5S, Visual Management, and the PDCA/A3 can be used to mitigate these root causes.

Leading way to accomplishing the third objective of the study, which is to develop a lean safety framework in chapter 5. Furthermore, these findings will be discussed in detail in chapter 5. The six companies are broken into three small-scale indigenous construction companies and three medium scale indigenous construction companies. Twenty-seven interviews were conducted with participants from these companies to present answers to the research question asked in this study. The chapter starts with the profile of the six companies interviewed and observed. After this, findings from the six companies will be presented and examined using themes created by the researcher.

#### **4.1. Profile of Six Case Companies**

From the data presented for small-scale indigenous companies one to three in the interview sample characteristics table 5 in section 3.7, it can be noted that across the interviewees, there are differences in the level of work experience. A1, A3, B2, B3, B4, C1 all have over 12 years working experience in the construction industry; B1, C2 both have over 10 years working experience; A4 has 8 years while A2 and B5 has 7 and 5 years of experience. For the medium scale indigenous companies one to three, D1, E4, F1 all have over 14 years work experience. D3, D4, E1, E2, F2, all have over 10 years work experience. D2, E3, E5, F3, F4, F5 all have over 6 years work experience. This is just to show that the interviewees for this study have some good level of experience in the construction industry in Nigeria and as such can offer valuable and experienced information regarding health and safety in the industry.

Below provides brief information about the three small scale and three medium scale companies.

##### **4.1.1. Small Scale Indigenous Company 1 (SSIC1)**

This company is a small-scale indigenous construction company located in Lagos State Nigeria. The company has about 20 employed staff on their pay roll and some other workers that are employed on pay as you work basis who are not staff of the company. The area of speciality of the company is in construction, infrastructure development, engineering and

design, and real estate. The company has undertaken over 120 construction projects within Nigeria and continues to embark on more for both private clients and government. In this company, a project manager, a project supervisor, and three labour workers were interviewed. Table (5) shows the sample characteristics for company one. Interviewees for this company have been given the codes A1 to A5. What each code represents is stated in the table. The table also contains the work experience of each participants and their job positions.

#### **4.1.2. Small Scale Indigenous Company 2 (SSIC2)**

This company is a small-scale indigenous construction company located in Lagos State Nigeria with about 5 to 10 employed staff, and other workers who are employed on pay as you work basis during projects. The company's area of specialty is mainly in building construction. They build residential houses, schools, offices, of different magnitudes for majorly private clients. The company has undertaken a lot of construction projects with the present being the building of a 2-floor residential building. In this company a project manager, and four labour workers were interviewed. Table (5) shows the sample characteristics for company two. Interviewees for this company have been given the codes B1 to B5. What each code represents is stated in the table. The table also contains the work experience of each participants and their job positions.

#### **4.1.3. Small Scale Indigenous Company 3 (SSIC3)**

This company is a promising small-scale indigenous construction company located in Lagos State Nigeria. The company is being managed by a team of construction professionals with over 50 years combined experience in the construction industry. The area of specialty of this company are in construction, structural steel fabrication and installation, and project development. This company is run on the principles of six sigma and believes in delivery of quality work for customer satisfaction. The company has about 20 to 30 employed staff on its pay roll and employs on pay as you work basis as well. In this company a project manager, and a safety officer were interviewed. Table (5) shows the sample characteristics for company three. Interviewees for this company have been given the codes C1 and C2. What each code

represents is stated in the table. The table also contains the work experience of each participants and their job positions.

#### **4.1.4. Medium Scale Indigenous Company 1 (MSIC)**

This company is a medium scale indigenous construction and engineering company located in Delta State Warri. The area of specialty of this company are in construction services, engineering, logistics, procurement, project management, plant installation, fabrication works, and equipment leasing. The staff strength of this company stands at over 150 staff. They have been involved in many construction and engineering projects mainly for clients in the oil and gas industry where they have functioned as sub-contractors to Shell, Pan Ocean, Southern Gas Constructors, and Chevron Nigeria Limited in the construction of the Chevron Escravos Gas to Liquid Project Plant in Escravos Warri Delta State. In this company, a project manager, safety officer and three labour staffs were interviewed. Table (5) shows the sample characteristics for this company. Interviewees have been given the codes D1 to D5. What each code represents is shown in the sample characteristics table.

#### **4.1.5. Medium Scale Indigenous Company 2 (MSIC)**

This company is a medium scale indigenous construction and engineering company based in Warri, Delta State. Nigeria. The company are into construction and civil engineering services. The company is also into mechanical equipment leasing. They have over 50 staff. The company has been involved in several construction and engineering projects within Delta State mainly within the oil and gas industry and are sub-contractors to Chevron Nigeria Limited where they have been involved in the construction phase of the Chevron Escravos Gas to Liquid Project Plant in Escravos Warri Delta State. Nigeria. Five staffs, which include a project manager, a safety officer and three labour workers were interviewed in this company. The sample characteristics is shown in table (5). Interviewees for this company have been given the codes E1 to E5. What each code represents is shown in the sample characteristics table.

#### 4.1.6. Medium Scale Indigenous Company 3 (MSIC)

This company is a Medium-Scale Indigenous Construction company in Edo State, Nigeria. The company is involved in roads and bridges design, construction, and rehabilitation. The company has over 100 staffs across different road construction projects in different States within Nigeria including Edo State. The company has and continues to handle road construction and other civil engineering projects for both private and government organisations. Five staff were interviewed from this company, which include a project supervisor and four labour workers. The interviewees have been given the codes F1 to F5, which is shown in the sample characteristics table (5).

For clarity purposes, table 5 is recalled below.

Company	Participant Code	Position	Working Experience (Years).	Company Type Classification	Location	
<b>SSIC 1</b>				<b>Small</b>	<b>Lagos State. Nig.</b>	
	A1	Project Manager	14			
	A2	Project Supervisor	7			
	A3	Carpenter	12			
	A4	Mason	8			
	A5	Electrician	8			
<b>SSIC 2</b>						<b>Lagos State Nig.</b>
	B1	Project Manager	11			
	B2	Electrician	14			
	B3	Carpenter	12			
	B4	Bricklayer	15			
	B5	Helper	5			
<b>SSIC 3</b>						<b>Lagos State. Nig.</b>
	C1	Project Manager	12			
	C2	Safety Officer	10			
<b>MSIC 1</b>					<b>Medium</b>	<b>Delta State. Nig.</b>
	DI	Project Manager	15			
	D2	Safety officer	8			
	D3	Mason	10			
	D4	Electrician	10			
<b>MSIC 2</b>					<b>Delta State. Nig.</b>	
	E1	Project Manager	10			

	E2	Safety Officer	12	
	E3	Carpenter	9	
	E4	Mason	15	
	E5	Welder	8	
<b>MSIC 3</b>				<b>Edo State. Nig.</b>
	F1	Project Supervisor	18	
	F2	Labour 1	11	
	F3	Labour 2	8	
	F4	Labour 3	8	
	F5	Labour 4	6	

The next sections provide the findings from the case studies of the three small-scale and three medium scale indigenous construction companies. The findings are presented under different themes created during the coding stage of the interviews. The themes are accident examples, root causes of accidents, trainings and provision of PPE's, management actions and inactions, 5S Methodology, Visual Management, and A3/PDCA.

## 4.2. Case Study 1: Small Scale Indigenous Company 1

### 4.2.1. Accident Examples

The essence of this theme is first to try to identify the types of accident mostly experienced by this company. Secondly, see how they align with the types of accidents listed, and how similar or dissimilar they are to those experienced by other small-scale indigenous companies. Thirdly, if their causes can be traced to the three root causes by Abdelhamid & Evereth (2000). Fourthly, see how the lean model to be created can take care of and help prevent these accidents.

Findings from participants in this company suggest that the following types of accidents as described by participants are prevalent: Fall due to no use of signage or barricade to warn workers of potential danger.

On this accident, participant A1 gave this narrative:

*“Let me give you a very recent one, it was a three-story building, the job was being down on a staircase, to be precise, the last landing. There is supposed to be a barricade, but nothing was put there, not even caution tape. A regular worker who has been passing there regularly, I do not know if he forgot that a job was going on there, he just passed there, through the stairway and he fell and broke his legs”*

This accident lead to the understanding that health and safety in this company is poor. A job of this nature would have required some risk analysis to be conducted. which would have pointed out the use of signage like barricades or caution tapes to warn people about the danger ahead. But none of such was made use of in this case, which has led to the accident in question. This is a case of accident happening due to unsafe work condition. If this unsafe condition were taken care of, the accident could have been prevented. Also, this also shows what participant A4 said concerning why some kinds of accident are so common. *“People don’t pay attention to their work environment”* If the accident victim in this case paid attention to his work environment, this accident could also have been avoided. This is where training of employees on safety is very important. Where trainings are not provided and things done in the right way, more accidents would be experienced as suggested by the narrative of participant A2 on the accident he experienced.

*“It was about 2 years ago in one of our sites where we were trying to cast a concrete drain. I*



*was in the site office when I heard a cry and came out to see what was happening. One of our workers who had no safety boots on had stepped on a 6inch nail that was standing erect on the floor. The nail entered deep into his foot. There is process when you want to cast a concrete drain, after giving elevations, the carpenter will come and get the form work braised, but unfortunately there was negligence on the part of the carpenter. He left a lot of nails on the floor; he did not pick up all of it after his own part of the job, which was done the day before. So, the mason came around to start his casting work the next day, as he was walking from one point to the other while doing his job, he was not wearing any safety boot, he stepped on the nail”*

This accident again has happened because of workers working in unsafe work conditions and the unsafe behaviour of workers by not taking care of the work environment before and after the start of work. One of the first requirements of a safe work environment is cleanliness, which happens because of having a good house-keeping culture. A dirty work environment is an accident laden environment. Therefore, it is important that before, while on, and after each task, housekeeping should be done to clean the work environment so that accidents like pierced by nails, slips, trips, and falls, etc can be eliminated. Two things could have been done to prevent this accident: housekeeping by the carpenter after he finished his work; housekeeping by the mason before he commenced his work especially seeing that the work environment is dirty; and wearing of a safety boot. These were ignored again due to lack of training on the job.

Participant A3 gave a narrative about a worker being hit by fallen object:

*“In one of the sites we worked in, in Victoria Island Lagos, it is a small site. A crane was carrying a bucket of concrete, as the crane is carrying the bucket to where it wanted to deliver the concrete, the hook holding the bucket just cut, and the person under the bucket, the bucket just fell on the person, pressed him down and the person died immediately on the spot”*

Accidents of this nature happen due to so many reasons. It could be due to lack of inspection of the crane before they made use of it hence it was not detected that the hook holding the bucket was not in good condition. It could be that it was inspected, and company is aware that the hook is due for changing but they still decide to use it, which happens in many cases. This has resulted in accidents killing a site worker. This again boils down to management failure in many areas, especially regarding training. As a starter, one of the things thought in safety training regarding loads is that one should never stand under a suspended load. Basic safety

training will teach anyone this. But failure to provide such trainings can be very costly and deadly. With this company, it can be stated that safety is not given a priority and as such things like training of employees and provision of PPE's are never done.

From participant A4, yet again the narrative deals with being pierced by nail.

*“Last week, one of our workers had a bad nail injury. He stepped on a nail while he was walking around the site. You know how construction sites are, some a very dirty with so many hazards everywhere. He was taken to a nearby chemist for treatment. He is still at home as we speak”*

Again, this accident points to workers working in unsafe conditions. Dirty work environment as earlier stated is an accident laden environment. Hence constant and proper housekeeping is very important to keep the site clean at all time so that hidden hazards are eliminated before they lead to accidents. Asked if housekeeping is done in the company, A4 responds: *“Sometimes we do, but it depends on who is working. I clean anywhere I want to work because of the training I have from my previous company in Abuja. We always do housekeeping down there. But here, some workers just start work without even cleaning the work environment”*

In this company, it is very clear that safety is not regarded as important, which is a major reason why housekeeping is never carried out and safety PPE's are seldomly provided. The next key theme “reasons for accidents” explain the reasons why some of these accidents happen.

#### **4.2.2. Reasons why Accidents Happen**

Part of this research is to find out the reasons for the root causes of accidents so that solutions can be made towards mitigating them.

As has been found in the previous section, this company has also experienced its own share of accidents, which has resulted in death, broken bones, puncture, etc from the brief examples given by participants. The reasons for these accidents are numerous and can range from human errors, to machine errors, negligence and ignorance as mentioned by participant A1 (Project Manager)

*“Accidents happen for so many reasons, for example we have human errors, which is inevitable, and sometimes in a site, we have mechanical equipment everywhere, machines can*

*develop faults resulting in machine error. Such errors can also occur from humans operating the machine [...]. Other reasons are due to negligence by management not putting necessary safety measures in place and ignorance”*

In looking at the various accident examples given in this company, it would be noted that negligence both from the company management and the workers played key roles in the occurrence of these accidents. Hence participant A2 mentioned that *“accidents occur due to negligence on the part of the company and negligence from the part of the employees”*. This comment is a true statement of fact. For example, in the accident involving the worker that fell by the stairs and broke his leg, had management provided training, workers would have known that barricades, caution tapes and or signs should have been placed where the stair landing task was ongoing to warn other workers about the potential danger ahead, but as A1 the Project Manager would mention, *“there is supposed to be a barricade, but nothing was put there, not even caution tape”*. This signifies a big failure by management to provide a safe work environment for its workers, which amounts to negligence. On the other hand, even the accident victim failed to pay attention to his work environment while carrying out his task hence the accident.

Furthermore, other causes of accidents from participants in this company was traced to lack of training, non-provision of PPE's, and carelessness as mentioned by A3 *“I will say accidents happen due to carelessness and lack of concentration on the job. Most times accidents happen by mistake due to maybe tiredness. But majorly I think it is due to lack of not using PPE's and lack of trainings”*. Participant A4 takes this further by adding poor housekeeping and no knowledge of the job. From observation of the site, it was discovered that the environment was very dirty with materials scattered all over the place. Walking through the site with the project manager, the researcher discovered that the site was very unorganised. The researcher practically saw a worker trip and fall while walking around the site. The project manager asked him what happened right in front of the researcher. His response was that he mistakenly hit his leg against one of the woods laying around. There seemed to be no housekeeping activities in this site.

### 4.2.3. Root Causes of Construction Accidents

When accidents happen on site, knowing the immediate cause of the accident alone and treating same cannot help in creating solution to the re-occurrence of such accidents. What happens is that such accident can repeat itself again unless the underlying issues concerning the cause of such accidents are traced and eliminated. Hence it is important in this study to find out the root causes of accident as the model to be created in this study will be channelled towards mitigating these root causes. Therefore, regarding root causes, A1, Project Manager for example stated that the root cause of accident is due to lack of information about the job and knowledge about hazards. In his words *“I cannot do what I do not know, but if I am trained and being trained, being informed, “I never knew, now I know”*. So, *lack of information is a major problem and the number one root cause of accidents. Some people don’t even know the importance of health and safety on site, but if they are informed and trained, they will know the importance and work safe such that accidents can be prevented”* Going further, A1 stated *“You see, once something is not safe, it has to do with how knowledgeable you are. If you are knowledgeable enough you can quickly see that the job is unsafe”*

The statement by A1 points to the area of being properly trained about health and safety on site as this is key to being able to gain knowledge about hazards and how to identify them when working on site.

While A4 recognises that training of workers about health and safety is necessary and absence of such will lead to workers working in unsafe conditions, he however puts the root cause of accidents on management failure. *“When management of a company is serious about health and safety, they make sure that they train their workers and provide all the PPE’s they need for their job. When management cannot do this, then the workers work in unsafe condition and accidents happen. So, the root cause of accident for me is management failure to take health and safety serious in their various companies”*. On his part, Participant A2 recognises management failure as a root cause. However, A2 also saw the root cause of accidents from another angle by stating that it is due to corruption practices by government health and safety agency representatives who instead of making sure companies abide by safety rules, would rather take bribe from these companies and ignore their duties. In his words *“Corruption. Corruption in the sense that the government has put in place health and safety policies and measures, to curb or to guide all contractors. Now the same government representatives, take*

*bribe from these companies and ignore their duty of making sure these companies comply with safety measures. So that is the major root cause to me”*

Regarding the accidents that have happened in this company, findings reveal that most times the root causes of the accident are never know because accidents are never investigated as stated by A3 *“If it is a big company, investigation will be conducted, but this is a small company, nothing like investigation was conducted. The only thing we know was what happened on that very day of the accident”*. When investigation is done, it appears such investigations are not properly conducted and as such the root causes are never known. For example, A1 speaking about the root cause of an accident stated: *“We checked and looked at the machine [...] but on that faithful day, nobody knows what happened. I asked him what happened, he said he just realised that as he was cutting, the disc came off and straight up to his veins. But what I felt was that probably he did not lock the disc very well while cutting”* The use of the words *“But what I felt was that probably he did not lock the disc very well while cutting”* was just an assumption and does not stand as the root cause. When told this is an assumption, A1 responds *“Yea it’s an assumption. I just told him when next he is working with such machine, he should put on his hand gloves because on this occasion, he was not putting on a hand glove”*.

#### **4.2.4. Trainings and Provision of PPE’s**

The importance of training workers on the use of tools and equipment, use of PPE’s and on knowledge about general safety on site has been iterated by various studies (Colligan & Cohen, 2004; Wilkins, 2011; Albert & Hallowel, 2013; HSE, 2013; Loosemore & Malouf, 2019). Many accidents leading to injuries happen on site due to workers inability to recognise and respond to hazard in the workplace. When hazards in the workplace are unrecognized by workers, such hazards expose the workers to unanticipated risks, which can result in big costly accidents. Hence, participant A4 would state that *“accident happen due to no knowledge of what hazards are and how to identify them. When I worked with the foreign construction company in Abuja, we were given a lot a training on the job. So, we are able to know hazards when we see them”*. With proper health and safety trainings workers can identify and recognize hazards in the workplace and respond to such hazards before they lead to accidents thereby improving safety performance. Also, trainings will make workers know the relevance of

wearing their PPE's during work, which can help stop or reduce injuries from accidents when they do happen. However, A4 stated that, *"I was not given any training when I started this job. The training I have is from where I worked before in a foreign (multinational) company in Abuja"*. Part of the primary responsibility of top management is the provision of trainings and PPE's for all employees on the job. Participant A2 Project Supervisor stated that *"In this company we provide the basic PPE's like Coveralls, helmets and safety boots"*. While it may be true that PPE's are provided in this company, sometimes it is just maybe safety boots that are provided, and these are given to just a few of the workers.

These findings suggest that in this company, top management are sometimes stubborn about providing trainings and making provision for PPE's. Observation of workers on site in this company showed some working with only safety boots, no hand gloves, no helmets, etc, and some had no form of PPE's on.

The statement by Participant A1, the Project Manager sums up how uninterested management can be towards safety in this company.

*"I continuously insist on provision of trainings and PPE's for employees even if it's by force through emails and through hand written flyers so that by the time the authority comes for inspection "If they do come" or come due to the fact that there is an accident on site, it will be on record that as a project manager, I made effort for workers to have their basic PPE's and training and top management will not be able to deny it because the emails will show this"*

This response iterates the fact that in this company and in so many of the indigenous construction companies in Nigeria, trainings and PPE's are never provided and where these are provided sometimes it is due to the continuous persistence of the project manager or safety officer where there is one. Also, in some cases where PPE's for example are provided, workers sell them instead of making use of them as stated by A2 *"I think what they (workers) normally do is, if they are provided with safety boots and other PPE's, some of them take it home and sell them"*. However, this happens when management does not give priority to health and safety of workers. Providing basic PPE's and trainings alone for workers cannot prevent accidents from happening. Making sure the workers understand the training, put the training to practice as well making sure they make use of the PPE's provided is what makes the difference. In

many small indigenous companies unfortunately, safety is not given a priority and as such not a concern for management.

#### **4.2.5. Management Actions and Inactions**

The actions and inactions of management towards safety is a big determinant of whether safety performance on site will be good or bad. Positive and proactive management action will lead to a positive safety culture, which would always in turn lead to safe work practice on site. The opposite of this can only lead to one thing: poor safety culture leading to unsafe work practices and therefore accidents. As A2 would state *“workers won’t obey or follow rules if we as management don’t lay down our authority. I can say 90% of disobedience to rules are due to management faults”*. In this company, management does not seem to be keen on the health and safety of their workers and as such their actions towards safety is way below the average mark. Speaking on management actions, A5 believes that *“the most important role management can play is to take safety seriously. When they take it serious, workers will take it seriously too and work safe”*. The Project Supervisor for this company had stated that workers sometimes sell the safety boots given to them to work with. Question then is what action does management take when things like this happen? The simple answer is none. Participants however believe that management should always take actions when cases like this arise. A3 stated *“like as I am now, if they (management) walk into the site and see me working without any safety PPE’s on, its either they should send me out of the site, or they give me a penalty”*. A2 blames the lack of actions on management: *“I can say it is also part of the company’s fault for not following up with a good safety culture”*.

Interestingly though, they seem to know and understand the importance of safety going by the words of the A1 the Project Manager *“As managements, we should be proactive and respond quickly to all safety issues at hand”* However, putting these into practice and action seems to be where the problem exist. A4 therefore suggest this: *“the most important role management can play is to take safety seriously. When they take it serious, workers will take it seriously too and work safe*. Why are indigenous small-scale companies lacking in this regard? A1 said: *“Because of the monetary part of health and safety, it also as a result of ignorance, negligence, it also because of the well learned people who knows there left from right and still choose to ignore health and safety”*.

#### 4.2.6. 5S Methodology

In this company, the concept of lean is unknown. When the 5S methodology was mentioned, employees did not know what it was. However, upon explanation of what 5S is and a video showing how 5S works was played to them, they understood and was excited about the workings of the 5S methodology. The Project Manager A1 said *“I think it’s a good process, it is not cumbersome, it is a planned process to make the task easier and safe. I love the orderliness of the process and I’m picturing how I can use it in my own daily work already”*. Going further, A1 stated thus *“it would make my job to be done in a more simplified manner. It brings about accountability in the sense that with the proper arrangement of tools, you know when a particular tool is missing and when it’s not missing”*. Speaking on the use of the 5S as a safety tool on site, A5 stated that *“the process is straight forward, and people will easily understand it”*. The 5S basically is about keeping the work environment clean through a systematic housekeeping process grounded on continuous improvement to improve among others, safety on site. A2 after watching the video stated thus: *“To tell you the truth, it is a wonderful approach to work site safety. It will be a nice system that will go a long way in rectifying the issues of accidents in construction sites. This is what we need in construction sites in this country, especially with indigenous companies”*.

It is however important to note that cleaning the work environment alone is not what classifies a good housekeeping. The continuity of the cleaning process, how it is carried out, and the culture built into the work team matters a lot as these are what creates a safe work environment. Hence the importance of the 5S methodology as a housekeeping tool. It uses five basic steps each starting with the letter “S” to systematically clean the work environment creating a place for everything and everything in its place to sustain a productive work environment built on the culture of continuous improvements. As A1 stated, *“it makes you set up your job in an organised manner and the beauty of it all is that when everyone comes here to look at it, they would appreciate it more when you are being organised”*

A2 however sees a problem with the fifth ‘S’, which stands for sustaining the 5S process. He stated that *“I think it’s a wonderful process. It is just about the self-discipline. The last S of the 5S (Sustain) I can say is one of the most important aspect because for someone to be doing such thing (repeating a process) continuously, takes dedication and is a problem”*. A2 and A4



thinks that the same management that will approve the use of the 5S in an organisation may still be the ones to fault in sustaining it due to poor safety culture. However, with proper management commitment, the 5S can be made a culture in any organisation and can become a part of employee's job routine as explained by A3 with reference to when he worked with Julius Berger, a big multinational company in Nigeria. A3 stated thus *"I worked a long time with Julius Berger and this cleaning (housekeeping) is a thing we do all the time, so it has become a part of me. Anywhere I work, I like to keep my work zone clean because it will help me work safe"*. For workers to understand and make use of the 5S in the right way, they need to as A1 suggest, be given training on 5S.

#### **4.2.7. Visual Management**

Visual management in construction involves among others, the use of visual signs to warn people about impending danger zones in the work environment. These signs help prevent accidents in construction sites. Speaking on its use for the aforementioned purpose, A1 stated thus *"It is good in that after you have lectured workers verbally, those signs would speak more to them. Once they are working and they look at it, they immediately remember what they have been taught and they see the danger ahead"*. A1 however believes that the 'key' to the effective use of visual signs in the workplace is on placement of these signs in the right place and at the right time; and making employees understand their purpose. His words: A1: *"the key is to be able to place them in the right place at the right time and to make the employees understand their purpose"*. Understanding the purpose of using visual signs can be achieved through training. Workers need to be trained to understand different types of signages and what they mean. A failure to train workers can render such signs useless even when they are made use of. This was highlighted by A4, he stated thus *"all we workers need is training because if you don't understand the signs, you can still become an accident victim even if the sign is there. So, training is needed"*.

In this company, workers report that they make use of visual signs and that the visual management tool is a good tool for accident prevention on site. A4 stated that *"we use it here and I have used it in my other jobs. It is a very good system of accident prevention"*. A2 stated that *"I noticed that you don't even need to tell anybody about the danger ahead, visual signs are like a language on its own. When people see the signs in the work site, it speaks to them."*

*Since we have been using, it is something that we do not do without. Without it, serious accidents could happen in the worksite”*

Going further, A1 project manager stated that *“it is a tool. I would encourage other engineers and other project managers to use”*. Interestingly, A2 believes combining the visual management and 5S would enable a safer work environment. He stated thus *“it will absolutely prevent accidents from happening on site, especially coupled with the 5S, the work site would be a safe place to work in”*.

#### **4.2.8. Problem Solving Framework (A3/PDCA)**

Participants in this company have not heard of or made use of the A3/PDCA problem solving framework before. However, after watching the video, which explains what these tools are, they believe it brings about efficiency in planning and can help organisations with problem solving and safety. For example, A4 stated that *“a framework like this can help organisations to know how to take care of their problems anytime a problem arises. So, I think it is a great process. It can help take care of safety issues on site”*. Furthermore, A2 stated that *“this tool itself brings about efficiency in planning and this would really help in reducing accidents on site”*.

The A3/PDCA problem solving framework focuses on finding the root cause of problems and providing countermeasures to address the identified problems including follow-ups. This to participants can help take care of safety issues on site. A2 said *“I think the combination of the A3/PDCA can systematically help with solving problems relating to health and safety in construction sites”*. An important area of the PDCA is that it is used for continuous improvement and management of organisations. Participants believe that repeated use of this process will create a culture of continuously improving work process. A2 stated that *“these tools can help solve problems and can also help in continuously improving work process”*. A1 stated that *“this A3/PDCA process can help improve health and safety on site through helping solve problems. Something you do repeatedly will end up being a part of you. Participants stated that they would recommend the use of the A3/PDCA framework.*

## 4.3. Case Study 2: Small Scale Indigenous Company 2

### 4.3.1. Accident Examples

The essence of this theme is first to try to identify the types of accident mostly experienced by this company. Secondly, see how they align with the types of accidents listed by participants and those listed in chapter 2, and how similar or dissimilar they are to those experienced by other small-scale indigenous companies. Thirdly, if their causes can be traced to the three root causes by Abdelhamid & Evereth (2000).

Participants in this company gave examples of accidents they have experienced or seen happen. These accidents ranged from fall from height, pierced by nail, hit by object, slips, trips, and falls, fall from scaffold, hit by flying object, machine cut accident etc.

Participant B2 gave a narrative of two accidents, one concerns fall from height and the other concerns hit by falling object. His narrative:

*“There was a site in Lekki area of Lagos State, we were working on a 4-Story building. One of our workers fell from the top floor and broke his leg. He did not use harness belt. I am sure if he had used a harness belt he would not have fallen.”*

This accident shows the relevance of safety training, provision of work equipment (PPE's) and strict follow-up by personnel in charge of safety. This non-use of a safety harness belt by the accident victim demonstrates the fact that safety is not given a priority in this company.

*“About 3 days ago, in this building we are working on now, one of our workers threw a stone down from the top floor. There is a hardhat I have that I work with. I just put the hardhat on and decided to walk around the site and check the job going on. As the worker on the top floor threw the stone, it hit me on my head. If I had not put on the hardhat, my head would have been broken by the object. Anything that has to do with safety is very good, but some people do not care about it. You see the big companies, they care about safety, but all these small ones don't care”*

With proper safety training, the personnel that threw the stone from the top floor would have known that in a work site people walk about and as such objects of whatever kinds must not be

thrown. This shows poor housekeeping behaviour. But a situation where workers behave in unsafe manners thereby putting other workers at risk suggest that indeed in this small company health and safety performance is poor. Asked if the accident concerning the worker that fell from the 4<sup>th</sup> floor was investigated to know the root causes, B2 responds: *“It was not investigated. They just rushed him to the hospital and work continued with the remaining workers on site”*.

Participant B4 gave a narrative of an accident involving stepping on a nail. His narrative:

*“There was a day I was working in the site, on a scaffold. I wanted to come down from the scaffolding, I did not know there was a used nail where I wanted to jump down on, I jumped from the scaffold point down on top of the used nail. And the nail got my leg. I used about 3 months in the house before I could move out anywhere”*.

This accident demonstrates the need for good housekeeping and discipline by employees. Proper housekeeping before the start of that job would have eliminated that nail from the work environment in the first place. Secondly, the personnel in question had no safety boots on, which again demonstrates a lack of priority for safety of workers. Thirdly, the injured personnel failed to identify the unsafe condition of the work environment. The root cause of this accident was also not investigated as stated by participant B4.

Participant B3’s narrative concerns falling from a wooden scaffold. His narrative:

*“We were working on a three-floor building. The scaffold was made with wooden stands, there was a worker that was on the scaffold doing a plastering job on the second floor. While he was plastering, the part of the scaffold he was standing on caved off and the worker fell. Luckily he did not die but he sustained a fatal injury, his leg was broken and was rushed to the hospital”*

Asked if this accident was investigated to determine its root cause, B3 responds “No, it wasn’t investigated. However, B3 stated thus: *“if the company had provided a harness belt for the worker and the worker was trained on how to use the harness. When where he was standing caved off, he would have been held back by the harness belt”*.

This accident demonstrates the need for proper inspection of work tools before they are used for work purposes and the need to always wear the required PPE for every job. Proper inspection of the scaffold before use would have shown that the scaffold was dangerous to stand on, and if he had a harness belt on, this would have prevented the fall.

Participant B1 the Project Manager gave a narrative that happened a day before this interview involving a metallic gate falling and cutting the hand of a worker due to non-use of hand gloves during lifting.

*“Yesterday we brought two gates that we want to use for the outer fence. In the process whereby, they want to bring down the gates, the gates are about 5meters long, there is no gloves, there is nothing. In the process whereby, they are bringing down the gate, the gate fell on one of the guys lifting it finger. The finger cut deep, and it was bleeding. That was what just happened yesterday. And in the process whereby they want to stand the gate in the fence also, there was another guy that sustained a minor bruise on his head”*. Asked why workers did not have their hand gloves and hard hats on when this task was going on, B1 replied *“We had no hand gloves on site”*.

This accident even though minor, demonstrates that in this company, necessary PPE’s are not provided for employees and the risk involved in each task is never discussed before embarking on the job as highlighted by B2: *“When I worked with one big company, we normally have safety meeting before we start any work in the site [...], but in many of the local companies, we just go straight to the job. No discussion of the job, it is assumed we all know what we want to do, so we go straight to the job. Bricklayers to their job, carpenters to their job, etc”*. This statement was further confirmed by the project manager B1 stating that: *“..... before every task, we know what and what is involved. [...]. We do not usually have a safety pep talk.*

This shows that in this company as in many indigenous companies, safety is not considered as important but rather the task completion as stated by B1: *“..... there should be safety awareness lessons, at least once in a week or once in two weeks. But what you find is that in Nigeria, especially with the indigenous contractors, all what the project managers are talking about are the task and task completion. Nobody is concerned about the safety issues arising from the task and the health and safety of the workers carrying out the task”*.

The last example from participant B5 describes a trip and fall accident: D5 narrates.

*“In one of our job, one of our workers fall on the stairway because he stepped on a sachet of water that someone leave on the floor. Someone drink the water from the sachet and drop it on the floor, the worker was carrying a pan with sand on his head going to the top floor. He did not see the sachet water on the floor, and he stepped on it. He slipped and fell with the head*

*pan containing the sand on his head. He had a lot of bruises on his body and dislocated one of his arms”.*

### **4.3.2. Reasons why Accidents Happen**

Interviewees indicated that accidents happen due to various reasons and factors, which results in either minor or major injuries or even death. According to B1, *“Accident happen for so many reasons. [.....] nonchalant attitude, employee negligence, and oversight”*. B1 however placed some of the reasons for this oversight, negligence, and nonchalant attitude on the part of workers on management. He stated, *“Management failure to provide necessary PPE's and trainings to workers can lead such workers to having accidents”*. Looking at the accident examples given by workers in this company, it can be noticed that the bulk of blames for the said accidents fall on management failures on the areas of providing trainings, provision of the needed and necessary PPE's for the jobs and their lacklustre attitude towards safety and the safety of their workers on site. B2 believes that management fail and do not have time for safety in small companies due to money issues. He states *“the big companies have time for safety. But these our local companies do not have time for it. Some local contractors can just approach you to help build this house, but they are not willing to spend money on safety”*. However, prevention is better than cure. Money spent on treatment of accident victims and payment of compensations can be much more expensive than what will be spent on safety.

Participants are also of the view that accident happen due to poor housekeeping. B2 stated that: *“There are some site that are rough, all the nails on the floor is never packed, all the woods on the floor are never packed. If a site is rough whereby no one cares about the cleanliness of the site, accidents must happen because workers basically work on top of the dirty. Another reason that can cause accident is lack of training. ....”*. This statement highlights the significance of carrying out good housekeeping in worksites. A clean worksite would eliminate hazards that can cause various types of accidents. However, a dirty work environments harbours many of these hazards thereby leading to accidents. An observation of the worksite of this company by the interviewer showed workers working in very dirty untidy environment with a lot of inherent hazards within. There was dirty scattered everywhere, pieces of woods here there, metal pieces and various levels of dirt. Housekeeping is not a practice in this company.

Aside negligence, lack of safety training, oversight, participants also stated other reasons. B5 stated that *“many times, workers are careless. Loss of concentration, [...]. Some accidents are natural. They must happen. Sometimes architectural design can cause accident to happen. Some workers think they cannot have accident because they think they know the job too much to make mistakes. They still end up having accident”*.

### **4.3.3. Root Causes of Construction Accidents**

The essence of this theme is to highlight the root causes of accidents from participants perspective. This is important because they work on sites and experience the accidents first-hand. Furthermore, their knowledge of the accidents and the root causes will play a very important role in creating a lean safety model that can mitigate the identified root causes. Therefore, regarding accident root causes, the Project Manager B1 stated thus: *“the root causes I would say are lack of orientation about the job, unawareness of task ahead and the risk involved in the particular task you are given. Because people are not aware of the work, some people do not have the skills, they just come into the site to work”*. This statement implies that with these small companies, many at times, workers have no orientation before going on the job and into site to work as stated by B1: *“most of these workers we are talking about are just unemployed youths, some are even graduates, with no jobs roaming the streets with nothing to do. They just need to fend for something for themselves and when they find out a construction job is going on in any location, they go to the sites to find out what is going on in the site and ask if they could be given a job for the day. Some gets the job maybe just for that day or for one week and start the jobs without even having any knowledge of the job they are performing, they don't really know what is involved in the job they are carrying out and the risk involved with that work. They do not get any training before the start of these jobs”*

This can put these sorts of workers and others working around them at risk due to no knowledge of what they set out to do and the risks involved. When they see hazards in the worksite, they cannot identify them, so they work around such hazards and even create more hazards as well. Hence elaborating more on this, B3 stated that *“I will say the root causes of construction accidents boils down to workers not being able to differentiate safe and unsafe work. Another root cause will be management failure to provide a safe work environment for workers and provision of trainings. [...]. This can lead to serious accidents.”*. This statement points to fact

that management has a very important role to play in accident prevention. Workers can only be trained on safety if management make provisions for such training. If workers are untrained about safety, truly as stated by B3, they will not have the capacity to know safe and unsafe work. Other participants in this company also see the inability of management to provide training for workers as the main root cause of construction accidents as elaborated by B2: *“Many workers don’t have safety training before coming to do this job, because of that, we sometimes make a lot of mistake, which lead to accident. So, if we have training, those mistakes will not be made, and we will not have these accidents. Because a lot of accident are caused by our actions, what we do and what we fail do. The root cause of accident for me will be lack of training of workers, and where management don’t provide any form of safety to make the worksite safe to work on”*. Findings also reveal that loss of concentration, and unavailability of PPE’s are root causes. Importantly, these whole narratives by participants about the root causes points towards lack of trainings, which is a management issue. Does management in this company provide trainings and PPE’s for employees? The theme training and provision of PPE’s will answer this question.

#### **4.3.4. Trainings and Provision of PPE’s**

First thing that was observed by the interviewer walking into the worksite of a project this company was working on was that majority of the workers had no forms of PPE’s on and were working in very dirty unsafe environment and in unsafe manner. Asked if these workers were given any form of training because with training, they should understand how unsafe their work environment is and how unsafe they are working without PPE’s on. The project manager B1 stated that: *“we don’t train workers because we only have a few admin staffs and don’t have stable labour workers. We sometime employ on a daily or weekly bases and these workers are just paid per day or per week with no contract. A worker can work today and not come tomorrow. We replace him with another worker and the money for training is not there”*. This explanation goes to suggest that in this company, training is never given to employees. However, the value of raining cannot be overemphasized. It gives workers the knowledge about site safety and how and what to do on site to work and remain safe. But as stated by B2 *“You see a lot of workers don’t know that some certain things they do can cause accident”* Going further, B2 stated that: *“but if the company provide training, workers will be able to know what can cause accident and when they see it, they can take care of that thing before it leads to*



*accidents. But the company do not train us*". This shows the relevance of training to employees. Speaking more on training, participants believe it is especially necessary for new workers without experience to be trained before coming on site to work. However, as it is in this company, such trainings are never provided.

Regarding issuance of PPE's, as earlier stated observation of workers on site in this company showed that majority of workers had no PPE's on. In fact, the researcher only saw one worker with a safety boot on and this worker (B4) state thus. *"the company did not provide me any safety boot, any coverall, any hard hat, or gloves, I normally use my own money to buy these things. The eye goggle that I use right now, I do not like dirty getting into my eyes, [...] As soon as I discovered the eye goggle, I brought from Julius Berger has expired, I went and bought another one for myself. If I do not use all these PPE's, anything like accidents can happen to me while I am working.* This suggest that some workers take the extra care to work safe, stay safe and so take charge over their own safety by spending their own money on safety PPE's where the company has not provided any. As it is with many of these small-scale indigenous companies, majority of them do not provide workers with any form of PPE's and when some do, participants believe they do not explain what they are for as stated by B5 *"many of these small contractors don't even provide PPE's. Some that provide just hand them to us without telling us why it is being given"*. Also, B2 stated that *"some companies will give safety boots and coverall, but some people do not know how to make use of the boots and coverall, especially those that have not worked with big companies before. If you give boots to some workers now, they will wear it for just one day and you will never see the boots again, some will tell you they are not comfortable working with PPE's, some sell the boots"*.

Handing PPE's to new employees without them knowing what they serve to do is as bad as not providing any form of PPE's at all. Workers need training on health and safety. Without this, they will not know the relevance of the PPE's they are issued with. Unfortunately, as stated by B1: *"majority of the construction workers do not really have the orientation of what health and safety is all about. They do not really know the reason why they are being given safety PPE's; they just believe that these are things they are entitled to as construction workers. They just believe it is part of their dress code. They just take it and use whenever they feel like it, some even take it home and do not bring it to work at all. So, there is lack of orientation when it has to do with personnel knowledge of health and safety.* Findings suggest that this lack of orientation about personal knowledge of health and safety is prevalent with indigenous small-

scale construction companies. Workers believe that if management provide the necessary trainings, and are strict with health and safety, workers will know how to use their PPE's, its relevance to their safety and will always make use of them.

#### **4.3.5. Management Actions and Inactions**

Participants believe that there are certain actions management of this company and others can take to reduce and stop accidents on site. B2 stated that: *Management should provide us with safety. I mean they should provide us with all the necessary PPE's we need to do our job and train us on how to use the PPE's and how we can identify unsafe conditions within us.* A failure to take this into consideration will always result in accidents on site. The project manager for this company who also happens to be the owner of the company also spoke on actions management can take towards protecting the health and safety of workers. B1 stated thus: *“the role I can say management can play is that, they should get a professional on health and safety, [....]. That is a safety officer that will be there monitoring every action and process of construction”* Furthermore, B1 stated that *“they should provide PPE's for workers and there should always be a foreman, someone in front of safety that moves round the site to check every action and to check the risk involved in every task that are given. Someone to make sure that workers wear their PPE's. There should be safety trainings to give the workers orientation whereby you know the risk involved in level to level, because as the work progresses, its either the safety measure reduces or increases depending on the extent of work. Management should always make sure that workers do housekeeping because poor housekeeping is the cause of so many accidents on site every day. Management should have a system whereby risk is assessed before workers go on site”*. These words from the project manager suggests that the management of this company does know what to do to protect the health and safety of their workers, however, due to reasons like the expensive nature of health and safety, they, like small-scale company one above don't give safety a priority.

#### **4.3.6. 5S Methodology**

Participants in this company are unaware of lean concept and the 5S methodology. However, after watching the video that details out what the 5S methodology is all about, plus some

explanations given by the researcher, some of the participants stated that they worked using the 5S methodology when they worked with multinational companies. For example, B4 stated thus: “..... when I was working with a big Chinese construction company here in Lagos, we use exactly this 5S system. In the morning before we start any job, that location we want to work in, we must arrange everywhere properly, the tools you want to use must be close to your side, the other tools you are not using for that day must be packed and kept neatly in the store so that they would not create nuisance in the work site resulting to injury or stress. The work location must always be clean to avoid and prevent accidents.”. The response suggests the effectiveness of 5S as a good housekeeping tool for construction safety. When asked if the 5S methodology in the Chinese construction firm helped prevent accidents in their work sites, B4 responds: “Yes, it helped because accident is reduced on the site, and it made our job quicker also”.

One of the major goals of the 5S methodology is keeping the work environment clean. B3 stated that: “When the work environment is clean, accidents like slips, trips and falls, nails and sharp objects piercing people’s legs, electric wire on the floor electrocuting workers that accidentally step on them, tools falling on someone, these and other accidents are all prevented” The stage by stage systematic housekeeping process of the 5S helps to ensure this goal is achieved creating a hazard free workplace. Hence B3 stated thus “I think the 5S is a good tool for accident prevention in the work site”.

The project manager of this company B1, had never heard of the 5S but however, after watching the video of the 5S, he believes that employing the 5S methodology on site will help save cost and time, improve safety, and make work run smoothly. B1 stated thus: “based on the video, the 5S is a very good process and a very good outline of stages whereby we need to put our site and other places of construction in such position where work will be able to go on smoothly, in low time, less cost and safely”. Asked if he would love to make use of this tool, B1 stated thus “This is a tool that can make a safer workplace and more organised workplace. I see myself using it in the future and will be doing some more research on the 5S”. Participants believes that what is needed for the success of this system is training of employees on 5S and sustaining the 5S. B5 however believes workers may pose a problem to the success of the 5S. He stated thus “Some workers may not be interested in cleaning before work and even some engineer will just be rushing you, so instead of allowing housekeeping they will say use that time to do your task”.

### **4.3.7. Visual Management**

The use of visual signs to warn people about danger zones in construction sites is important for accident prevention purposes. After watching the video on the use of visual signs, participants stated that they are familiar with and have made use of visual signs in companies they have previously worked with and this present company they also make use of signs. B4 stated thus: *“I have used it so many times, even in the Chinese company, we use signs to warn workers about dangers. Even in this project we are using it”*. Further, B5 said: *“We have some signs on this site even. Sign makes me know where there is danger, and I won’t go there”*. Observation also showed there were signs positioned in some locations on the work site of this company. This suggest that even though the safety practice in this company is low, the company still does have some form of safety practice in place. In this case the use of visual signs for accident prevention. Many construction labour workers are uneducated and cannot read. The project manager B1 believes that *“visual signs give direct precautionary measures because people that cannot read can understand signs, and if it is well placed in the right place, it can eradicate a lot of accident”*. This statement however raises two salient questions regarding understanding signs and knowing the right places to place the signs on site. Just placing signs on site without educating workers on what the signs stands for, and how to strategically place them will not prevent accidents from happening. Hence B5 stated thus *“But sometimes using signs alone cannot help prevent some workers from falling victims of accidents. Workers still need to be trained on signs and what they mean “*. This statement suggests that participants understands the need for training of workers on the use of visual signs on sites to get the full benefit of its use. Participants all agree that when visual signs were used in the various places they have worked in, they helped with accident prevention. They therefore believe visual management is a good safety tool and would recommend its use for construction safety.

### **4.3.8. Problem Solving Framework (A3/PDCA)**

Participants have not heard of the A3/PDCA problem solving framework before, however, after watching the video of the A3/PDCA and some explanations, participants believe the workability of this tool. B1 stated: *“well I think it is a concise way of solving problems, whereby all issues are addressed, and counter measures are listed out to tackle the issues thereby solving the problem without losing focus”*. Others said it is a good problem-solving tool, stating

that they have seen certain element of the A3/PDCA like the 5why root cause analysis tool being made use of when they worked with multinational construction firms during accident root cause investigation process. For example, B2 stated thus *“It is a great tool for problem solving in the workplace. I like the sequence of event from how you plan to the act stage. With this you can see problems and identify where the problems are from on time and correct the problems. That 5why was used in Julius Berger when they are investigating accidents to find the root cause”*. Although participants believe the A3/PDCA is a good problem-solving tool, they state that understanding the tool and how it works is important. B3 stated thus *“..... All that one need is knowledge about how the tool work. This framework can help the 5S and the visual management because when there’s an accident or a problem during the job, to find the root cause of the problem, the A3/PDCA can be used”*. Regarding the use of this tool for solving problems relating to health and safety on site, participants believe the tool is very useful. B1 stated thus *“well the A3/PDCA cycle is a technique that aims at solving problems. Therefore, when applied on problems facing the health and safety of workers on site it can also be very useful”*. All participants stated they will recommend the use of this tool.

#### **4.4. Case Study 3: Small-Scale Indigenous Company 3**

In this company, only two staffs were interviewed, a project manager and a safety officer.

##### **4.4.1. Accident Examples**

Participants in this company gave examples of accidents they have experienced or seen happen. These accidents described here were basically fall from height due to being struck by moving object (crane) and hit by falling object. The first example is given by the Project Manager C1.

*“In the last site I was on before I joined this company, we had a major accident. While trying to strip form work, we usually use tape harness to do form work for our walls. We were doing share wall. In trying to strip the form work, apparently a carpenter did not pay attention that a crane was coming down, so, the crane lifted up the panel, based on the site report that I read, and hit the carpenter, the carpenter fell from level 15 down, [.....] the panel fell down with the carpenter, and fell on 2 guys on the ground floor. [...] So, the carpenter died immediately, the expatriate who was in charge of our mechanical activities also died, then the guy that usually comes to work on our crane who is a sub-contractor was very much badly injured”.*

C1 was asked if the accident was investigated to determine the root cause, C1 stated that it was investigated and root cause was determined, however, C1 does not remember what the root cause of the accident was anymore. The researcher however thinks one of the root causes will be failure to pay full attention to the work environment by both the crane operator and the carpenter.

The second example is given by the safety officer for this company C2:

*“There was one, from about 6 floors of a 12-floor building, one of the labours was coming out of the building on the ground floor, not knowing that some people where working in the roof top where we have an opening. A piece of wood, somebody up there just mistakenly kicked it, about 2meter, fell from the roof, and as the labour worker was coming out the wood fell straight to his head. Thank God he was using his hard hat, but the hard hat got torn into two and he was on the floor. What happened, he could not say anything. We called emergency and rushed him to the hospital. Lucky for him it was just a small impact. But the question is if he was not*

*wearing his hardhat that is a big fatality. That is death instantly. Just because of that impact only, he almost lost consciousness. But if that wood had stricken his head directly, that is death”*

This accident justifies the importance of wearing PPE’s in your work environment. The absence of a hard hat on the head of the victim of this accident would have resulted in death, luckily for the victim, he had his hard hat on and that prevented the full impact of the fallen object hitting straight on his head. This shows the need for companies to provide necessary PPE’s for employees and train them on the relevance of having their PPE’s on. However, the housekeeping culture here seems to be poor and there seem to be a failure around training, which is a management failure.

C2 gave another accident example:

*“Normally, before any job, they print out and give us the schedule, but this very task was not planned for. All we knew was that an accident occurred. In this incidence that occurred, they were losing form work from the lead shaft, so, safety department never knew that they were to do that job that day. The person losing the form work, fell from the top of the other slab down, and he sustained back injury, and we rushed him to the hospital”*

Asked if this accident was investigated to find out the root cause, C2 explains:

*We set up the investigation team and we asked, where is the job safety analysis form for this job, none. Who permit you to do the job, he says it is the supervisor, we called the supervisor and asked, what happened, why can’t you inform us before you do this job? No answer. That is why I said, some leadership/management need to know the essence of safety. The root cause was that there was no job hazard analysis. There was no permit to work.*

With a job hazard analysis, the job would have been discussed and the job area would have been inspected to determine and identify the risk involved in this job. However, the supervisor seems to have gone ahead to perform he job without going through normal safety procedures, which has resulted in this accident.

#### **4.4.2. Reasons why Accidents Happen**

The two participants for this company stated various reasons why accidents happen. C1 stated thus: *“Well, before my mind set is accidents happen because somebody did not pay attention*

to what he or she is doing, he has issues in his family, and he has carried same to work". C1 however stated that after the training she got working in this present company, her thoughts on this change. C1 stated further: "*But now, I want to say [...] that BEFORE you start a job, you have to do job hazard analysis, job safety analysis JSA. I believe that if that is implemented, all those possible causes would have been identified*". This suggests that failure to carry out a job hazard analysis or job safety analysis before the start of any job are the main reasons that accidents happen on site. However, not all construction companies go through that process of carrying out a job safety or hazard analysis before the start their task. If workers are not trained on these processes, they cannot carry out such analysis. On his part, the safety officer C2 stated thus: "*Well, one of the main reasons is that most workers do not really pay attention to hazards. They feel that they can go around it, and it will not hurt them, but the reverse is always the case. Also, some people are careless, over confidence; what do I mean by over confidence, they will tell you I have been doing this job for years, and they say nothing has happened, they believe God so much, saying we have prayed it will not happen, but, accident does not respect anybody even if you have prayed, and it want to happen, it will happen. If you are careless, if you are not observant about the it, it will happen. Those are some of the things I see as the major causes of accidents*". Participants also stated management failure to provide training and PPE's for employees, and where PPE's are provided, failure by workers to use the PPE's, and enforcement of safety rules on site by management as parts of what could lead to accidents.

#### **4.4.3. Root Causes of Construction Accidents**

Speaking about the root causes of construction accidents, the project manager C1 stated thus: "*I will say based on the trainings I have; the root causes of accidents is inability to analyse the work that is to be done*". This statement suggests the need for construction companies to take time to sit down analyse whatever task that is to be done, identify the risks involved in the tasks, proffer ways, by which such risks can be eliminated, eliminate the identified risks, before embarking on carrying out that task. Unfortunately, many indigenous small-scale construction firms do not do this because they do not take safety as an important as aspect of the job. However, in this company, respondents stated that they take safety seriously, analyse the risks involved in their jobs, and identify the safest ways to do carry out the task, before embarking on them. For example, the safety officer C2 stated thus: "*Before any project commences, we have what we call risk assessment, with the project team, we seat together, we brainstorm,*



*what are the risks associated with this project. We itemize them, then we now categorise them, are they high risks, are they low risks, are they negligible, are they just insignificant, then we spell them out, there is a risk metrics that is used as a standard internationally. We make use of it, then we analyse all the risk, and proffer solutions to those identified risk. A risk assessment is key in every project and task we do”.*

Speaking further on root causes of accidents, the safety manager C2 adds: *“failure for you to identify the hazard in your work area before you start will lead to an accident. Because we are talking now about the construction industry. [...] All unsafe conditions, unsafe behaviours, unsafe activities, identify them before you start the job. If you are able to identify them, at least, you reduce the occurrence of accidents to a barest minimum, and you will be able to contain it and still perform the job safely and achieve your goal. Failure to identify hazards in the work areas are the root causes of accidents”.* The ability to identify the hazards in the work area would depend on if the workers have been trained on site safety. C2 also stated other root causes thus: *“I do always lay emphases on this; negligence. In our country (Nigeria), in our environment, negligence on the part of the workers, behavioural approach to work, not paying attention to details, and over confidence are also root causes of accidents. Because if you have conducted training, you have put all the laws in place and all these things are still happening, what is the root cause? So, it boils down to behaviour and attitude towards safety”.* Are workers given safety trainings in this company? The theme on trainings and provision of PPE’s will answer this question.

#### **4.4.4. Trainings and Provision of PPE’s**

On the first day the researcher visited the office of this company, two important things were observed by the researcher while waiting at the reception to meet with the safety officer. The safety officer was conducting a safety training in one of the rooms in the office, and there was another man also waiting to see the safety officer at the reception with a big bag containing samples of safety PPE’s the company was trying to purchase for its employees. This suggests that this company believes in the benefits of trainings and provisions of PPE’s to the health and safety of its employees. Regarding training, project manager C1 stated thus: *“we have a safety officer, he just returned from the site, he goes there to train people”.* In fact, in this company, training is not seen as just a classroom exercise, because sometimes behavioural attitude can

override training. C2 believes that training can be conducted for employees, however some of them will still go out to the field and misbehave thereby causing accidents. So therefore, training must be taken beyond the classroom and to the field as stated by safety officer C2: *“when I say training, it goes beyond just classroom training, but going to the field and practicalizing it and go see for yourself that, the things they are doing is right. I go on site to monitor them”*.

Regarding provision of PPE's, the project manager C1 stated thus: *“we issue PPE's to our employees”*. However, C1 further stated that *“when you issue PPE's to employees, they do not use them, or they will appear to use them only when they see that the safety officer is coming. You know how it works on site. Some of them will not use them”*. The safety officer C2 stated that this negligence to not want to use the issued PPE's could lead to accident and hence the relevance of training of employees. C2 stated thus: *Yes, we provide PPE's, but negligence of the workers when they are not ready to use it could lead also to accidents and the rest. This is always something that need to be discussed and that is why we conduct training here. To tell people that look, the resultant effect of accidents is on you the victim of that accident”*.

#### **4.4.5. Management Actions and Inactions**

Participants believe that management have a lot of positive roles to play towards accident prevention on site through their actions. One of such roles according to the project manager is training of employees. C1 states: *“first, there is a place of training, in training you have enlightenment”*. Further, the project manager also talked about provision of PPE's and creating a safe work environment for workers. C1 states thus: *“then also, provision of the PPE's, and then, aside that, you know it is not just providing PPE's, you have to make the environment safe for work. Where you need to provide mobile crane, you provide mobile crane, where you need to provide mixer, provide mixer, do not say go and use your shovel, do not cut corners. So, basically, that's what I am saying”*. Supporting these statements further, the safety officer stated that management support is important and without this support, even if a company have a safety officer, target in terms of health and safety performance in the company will not be achieved. C2 states thus:

*“There are two things now, if you have an organisation and the management is not supporting safety, nothing can be achieved until the orientation of the management towards health and*

*safety changes. So, health and safety start from top, if the managing director does not support health and safety, there is nothing the health and safety manager will do to achieve his target. Now, for instance, it is not the workers that will buy PPE's for themselves. According to the law, the organisation provides personal protective equipment for the work force. Now you are working on a construction site, people are wearing flip flops to work, and you are the manager of the organisation and you come to the site, you don't look at it all, you don't care, and you have a safety officer. Can I the safety officer now go and ask the workers, hey where is your safety shoe? The worker can get angry and throw you anything, saying did you give me any safety shoe? That is where management comes in, management must drive it. Management drive towards safety is very important".*

Importantly however, in this company, management give full support to health and safety as seen in this statement by C2: *"we have a safety plan that guides our operations in the safety department. So, for every project site, safety is involved. Before any job commences at all, safety needs to go for inspections and advice management that this and this are the things to be put in place. Good you came in when we were discussing about those PPE's. It is a fall out of the meeting we held last week for one of our projects. I told the management that before we start this project, some of these things must be put in place, and the management quickly agreed, and they called the supplier to begin to send the equipment. So, that is our management approach".* Regarding non-use of PPE's when issued to workers on site, strict decisions are taken by management in this company. C2 stated thus: *"I can decide to give you hard hat and you say you are not using it, the only thing for me to enforce it, is either I send you away from my site, if you don't want to use it, then leave my site. I know our project managers that do that also. If you are not ready to comply, which means you are tired of working, you are sent out".*

From observations and through deductions from interviewing the two participants from this company, this is a small-scale indigenous construction company that regards safety as important and as such takes the health and safety of their employees seriously. Why is this small-scale construction company different from others of its likes in terms of safety? C2 stated that the background training of the Managing Director of the company is what influences this idea. *"Our MD knows the importance of safety and lays emphases on safety".*

#### 4.4.6. 5S Methodology

Participants in this company have awareness about lean, specifically six-sigma. However, when 5S methodology was mentioned to them, they stated that they have never heard of it. A video that details what the 5S methodology was all about was however played to them and some explanations was also made to them by the researcher. Upon watching the video, the safety officer stated that he had made use of the 5S when he worked in a power plant. C2 stated: *“I have used this concept before. I once worked in a power plant some years ago, so, we made use of the 5S in the workshop”*. C2 also stated that the 5S helped in a great to improve safety in the power plant. C2 stated that presently, the housekeeping process in this company he is with is not okay, however, they are trying to introduce proper housekeeping by implementing this 5S method as a method of reducing accidents in the company. C2 states: *“we are trying to presently implement this process, it is not quiet long I joined them, but I am trying to bring proper housekeeping in as one of our methods of reducing accidents. Like I said earlier, we are lean oriented in this organisation and we are trying to train employees about the lean concept so that employees will have the idea of what lean is. This is so that it will grow along with the company. You know, it is a gradual thing, so, gradually employees will begin to understand what the concept is and how to key into it”*. On the part of the project manager C1, she believes housekeeping is very important in maintaining safety in a construction site. C1 states thus: *“I believe that housekeeping is key in a construction site. As soon as that has been properly taken care of, in my own opinion it reduces the risk of an accident occurring to a very large extent, like 90%. Because, if you are on a clean site, the construction manager can easily observe possible hazards and causes of accidents. If the site is clean there is no obstruction, you are seeing an acrow-prop that is not properly positioned, you are seeing a scaffold that is not well erected, you are seeing a worker that is not properly kitted, there are no wood lines, no heaps of refuse here and there, no rubbish scattered everywhere. I think it goes a long way in improving health and safety on site”*. The safety officer C2 believes that if the 5S can be made operational in the company, it would help reduce his stress of work. C2 took the discussion to toolbox arrangements and stated thus: *“..... Like when you were showing me the video, if you looked at the tool box, it was well arranged, but if it were not to be well arranged and everything just packed inside, you will not know if any of the tools are missing. It is only when you want to make use of it that you start asking, where are the spanner, hammer, etc.*

*[...]. But if it is well arranged, you will see the tools you need immediately. It makes the job easy and faster”.*

The 5S methodology is all about maintaining a good housekeeping standard to keep the workplace clean and free from hazards. However, to maintain this good housekeeping standard in any organisation, both management and employees must be safety compliant and work with the housekeeping system. The key to working with this system and understanding its use is centred on training of employees on 5S. As stated by C2: *“training is the key, without training, workers cannot and will not understand how to use the system and how the system works”*. C2 believes he can create teams for training purpose for the 5S and the system can be maintained in the company provided management agrees to it. C2 ended his comment thus: *“I must tell you my management is already on something like this and they are ready to implement it full force. If we make use of these 5S concept and everybody key into it, it will reduce to the barest minimum, accidents on site”*.

Both participants stated they will recommend the use of the 5S methodology in construction sites to improve safety.

#### **4.4.7. Visual Management**

Speaking on the use of visual signs to warn people about danger in the worksite, participants stated that they have used this tool severally. They have it in their sites presently, and are even designing more as noted by the statement of the safety officer C2: *“we have so many visual signages already designed in the office, and on site and I am even expecting the designer to come in and design more”*. Participants believe that visual management cannot be overruled in terms of safety on site as stated by C2: *“It is a warning sign and even though if you as the safety officer is not there, it speaks for you. [...] provided you have placed the sign, then it is already speaking on your behalf and telling people this place is dangerous, do not go there. You are working in a confined space, and you do not know that the place is a confined space because everywhere is sealed up. By placing signs there to show that this place is confined, [...], it sends a great warning to anyone working in that space and those working around it. So, visual sign is very good”*. Participants believe that visual signs should be displayed over the work area and that companies should ensure that employees understand what the signs are by not just using letters but also animations. As stated by C2: *“not everybody is educated to read in our*

*construction sites in Nigeria but they know what they are doing in terms of the job, so, animations, if you are to use your hard hat, put the hard hat as an animation on the sign, let the person know it is a hard hat, if it is goggle, put it as an animation, let the workers know goggles are needed. All these visual signs are very good in our construction sites”*. However, the project manager thinks the use of visual signs alone is not enough to keep a safe environment, housekeeping and enlightenment is also needed. C1 states thus: *“for where we are now in this country, I don’t think the use of signs alone is enough for us, housekeeping first, then we have to pay attention to enlightening the workers, because if you just put signs and they don’t understand, it is a problem. [...] if you take inventory, most people, or larger percentage of people that work on site are unskilled labour, or semi-skilled labour, and they are the ones directly involved in the project. [...] So, I would say using signage is good, but they must be enlightened of what the signs represents. Training is important, prep talk in the morning, it does not have to be an hour thing, just few minutes to educate workers”*. Participants believe with proper training of workers on working with signs, combined with good housekeeping, accidents will be prevented on site and health and safety will improve. Participants all recommended its use for construction safety. C2 stated that the use of visual signs should be encouraged and be used always on sites.

#### **4.4.8. Problem Solving Framework (A3/PDCA)**

In this company, participants have not heard of or made use of the A3/PDCA problem solving framework, Participants stated that when they have problems, they normally sit over the problem and discuss the likely causes and provide a solution based on the outcome of their discussions. However, after introducing the A3/PDCA to them, participants believe it a great tool that can be employed to solve problems. C1 stated thus: *“it’s a less time and effort consuming, systematic method of solving problems”*. Speaking more about this tool, C2 stated thus: *“it will make the job process to be easy to approach because once you have any problem, it makes it easier for you to solve the problem. What is needed is to understand how to use the framework. So, the PDCA/A3 framework is a good way to approach solving problems in the workplace”* Participant also stated that this framework can improve efficiency, quality and safety through its continuous improvement ability. C2 stated thus: *“it is a good tool because it will make you to know what you are doing, your direction when you are solving problems and the steps you will take to solve the problems. So, it’s just a continuous way of improving your*

*work in terms of quality and safety*". However, participants also stated that proper training is needed to really understand how to effectively use the tool. Participants all recommended the tool.

## 4.5. Case Study 4: Medium Scale Indigenous Company 1

### 4.5.1. Accident Examples

The first accident example given here is by the company safety officer D2 about a laceration accident. D2 narrates:

*“This accident concerns the issue of laceration, in which one of the fingers of one of our workers was almost cut off. They were trying to position some objects, and in the process of lifting the object, the workers hand was trapped. Luckily, it was just a medical case. This was reported, the worker was treated, the accident investigated, and the lessons learned was shared, and people learned from it”.*

The second accident example is about an incident that did not result in fatalities due to workers working with the right tools and PPE’s. The incident however has a learning point, which is why it is being shared here. This was given by one of the labour staffs D4.

*“We were doing excavation on a particular area, and there was a live cable buried underground. So, in the process of excavating, we were lucky we were putting on the right PPE’s because we struck the armoured cable underneath. Luckily, we saw it on time and because of the PPE we were wearing and the way the jack hammer was designed, we were not harmed”.*

The learning point regarding this accident is that with the right PPE’s and the right tools, some very fatal accidents can be prevented, and lessons can be learnt from such. One of such is this narrated by D4.

The last example here is given by the Project Manager D1 about a case of a worker who cut his fingers because he was working under the influence of marijuana.

D1 narrates: *“there was a case, somebody that was working on that faithful day, we brought modules to be stored. These modules have been stored for some months. So, the fester (what they use to hold the pipes, so that we can do tying on the other end so that the pipe will position properly) was being cut by a worker. After cutting, remaining the last one, he did not watch very well, he did not position well, immediately he cut the last one, the filters snapped and almost cut off one of his fingers. The case was reported to me [.....] and after treatment, we had to drug test. This thing that happened, is it that this man was not conscious of his self or*



*what happened? Is it that he was under the influence of something? We were trying to trace the root cause. When we tested him, he tested positive, not alcohol, he took marijuana, [...] he is already sacked, and he cannot come back to the project”.*

#### **4.5.2. Reasons Why Accidents Happen**

Participants in this company stated various reasons why accidents happen on site. These reasons ranged from human error due to wrong mindset, negligence, overconfidence, etc. For example, the company safety officer D2 stated these reasons:

*“The main reasons I will say are due to human error, and like I told you, contracts are not too good. Whether you like it or not, you have these workers talking about the salary, thinking about it, and others. Although yes, their mindset should be on the job, but we are all humans, we have individual stressors. Some persons might be able to identify these stressors and eliminate them, but some might not be able to identify and eliminate them. Some will just look for a way to manage it. But not all. Negligence is also a reason, then importantly, overconfidence. Some workers feel they know it all. They believe they have experience in the job and ignore safety. Other reasons would include act of God, management failure, lack of safety orientation and when supervisors and project managers rush the job thereby making the workers work in a rush”.*

This comment dives into a lot of issues in relation to why accidents happen on site in this company. Monthly take home pay of workers is one of such issues. If take home pay is poor, it affects the mindset of personnel and with such mindset on site, full attention cannot be paid to the job and so accidents can occur. Another issue mentioned by the participant deals with overconfidence. The comment suggests that people that have performed particular task for a long time think they have much experience not to fall prey to accidents. The reverse is always the case. Three other very important points were listed here by the participant; management failure, lack of orientation, and when supervisors and project managers rush the job. The whole three can be placed on management failure. The comment suggests the importance of management to a safe work environment.

Speaking further on reasons why accidents happen, the project manager for the company D1 stated thus: *“some are man cause, some are machine failure. Under man cause, you have things*

*like carelessness, attitude, over confidence. Then some are caused by natural disaster and that depends on the one you are looking at, then drugs and alcohol usage”.*

Accidents resulting from natural disasters or act of God as some may call it are very unpredictable and so cannot be easily controlled. However, those that are caused by human errors can be controlled and eliminated through for example trainings, provision of PPE’s, having good safety plans to assess risk and identify hazards in the work environment. The comment point to management failure as causes of most human error accidents.

Other participants view on the reason why accidents happen are like those already listed here and all fall under management failure. For example, D4 stated the following as reasons why accidents happen:

*“Unsafe work behaviour of workers, unsafe work environment, lack of safety orientation and training, not working with PPE’s, machine failure, dirty work environment, management failure, then act of God”*

When workers work or act in unsafe manners when performing tasks, this can be due to many reasons, which include but not limited to lack of training on safe and unsafe work behaviours, presence of training but lack of monitoring to ensure that what is learnt during training is put to practice, non-provision and use of work PPE’s and where the company provides PPE’s lack of monitoring to ensure that workers make use of the PPE’s, supervisors rush to complete the task thereby encouraging workers to work in unsafe manner. Even though workers can be blamed for unsafe behaviours, the root of these unsafe behaviours all boils down to management failure. Same goes with unsafe work environment. It is management duty to ensure that workers work in safe clean environment, however, their failure to provide these can lead to accidents. This comment therefore again points to management failure as the main reasons for accidents.

#### **4.5.3. Root Causes of Construction Accidents**

*“Here in Nigeria we have a parable: Slapping me, is just the cause of a fight, what we are looking for is what brought about the slap. That is the real root cause”.*

This was a statement from participant D1, the project manager for this company.

The essence of this theme is to highlight the root causes of accidents from participants perspective. This is important because they work on sites and experience the accidents first-hand. Furthermore, their knowledge of the accidents and the root causes will play a very important role in creating a lean safety model that can mitigate the identified root causes. Looking at the root cause of construction accident from the angle of system failure and giving very comprehensive points regarding same, the safety officer D2 stated thus:

*“When you are doing accident investigation, you find out that there is a system failure. Now, system failure is mostly the root cause of most of the accidents that happen on site. This is because you find out that maybe from the management level, someone fails to do his job. Now let us look at an unsafe condition that you have seen, you fail to identify it, that unsafe condition on its own is a near miss, now you did not report it, it might lead to an accident. [...]. In a root cause analysis, there are various angles to root cause. You check this, you check that, you check this. That is why I said system failure, is always on top, but there are various branches that could lead to it”.*

Speaking further, D2 explains: *Take for instance, you see an unsafe condition, if you had corrected it immediately, accident would be prevented, but now, you did not correct it, maybe you were carried away with the job, and there is pressure that you need to finish the job in less than say for example two hours. That is where supervision needs to come in, in as much as you are supervising the job, you should be able to look around the conditions of where your guys are working to ensure that they are okay. So, that’s the system failure”.* The comments suggest how the inaction of management towards safety at every level can lead to the root causes of accident. The action and inaction a worker take towards working safe primarily boils down to the lessons on safe practice that has been instilled in such worker by the organisation the worker works for through trainings, and the safety practice in operation in such organisation. What is constant in construction organisation without safety practice are accidents and deaths as D3 would state: *“many accidents that lead to injury and death happen because of no safety. A lot of construction workers have died, and many have injuries that cannot make them be able to work again because of this”.* Many indigenous companies don’t have regard for safety as justified by D3: *“Our local contractors here don’t regard safety. It is only a few local companies that you can find practising safety and most times it is maybe because they have contracts with big multinational companies and these big companies see safety as very important”.* When management of a construction organisation are not interested in safety, then

their sites become accidents heavens. Is this company safety compliant and do they regard the health and safety of their workers to want to prevent them from accidents? The answer to this will be discovered in the next theme.

Furthermore, other participants have also stated what they think are the root causes of construction accidents. They fall on management failure and workers stubbornness. For example, D5 stated thus:

*“For me, I think it is due to no knowledge of the job because of lack of training. When you are not trained for the job, you will not be able to identify a hazard when you see them or understand how hazards arise in your work environment. Sometimes we see hazards and work around it, but with training, we will know that such hazard should be taken off before work continues. These are what I think the root causes are”.*

This comment suggests the importance of safety training in construction organisations. Many root causes of accidents happen to be from unidentified hazards that are around the work environment that as D5 stated are not identified and eliminated before, during and after work. Again, this comment takes us back to the system failure spoken about by the safety officer D2. A system failure due to management inaction will lead to failure in so many ends of the organisation safety-wise. One of such failures include where supervisors do not respect safe work practice and are only after the end of the job irrespective of how this end is achieved. Another failure is not providing trainings and PPE’s for workers, not having safe work practice in place, and hospitals for workers. Do this company provide all of this? The theme trainings and provision of PPE’s addresses this.

#### **4.5.4. Trainings and Provision of PPE’s**

First thing the researcher observed walking to the site of this company is that workers were kitted up with their safety PPE’s. In the safety office where the interview took place were several safety metrics and notices pinned to a safety board on papers with Chevron logo. The company is a sub-contractor to Chevron. Seeing these notices in the safety office and the workers with PPE’s on was a first indicator to suggest that this company are safety compliant. Part of the step’s companies can take towards ensuring that the health and safety of their workers are looked after is provision of trainings and PPE’s for workers. These can help reduce

accidents on site. Regarding this issue in this company, participants stated that they are provided trainings and PPE's. For example, D3 stated thus: *“the company comply with health and safety. They provide us with trainings through a seven days induction program before you go on site and we have other trainings occasionally”*. Speaking further, D3 stated thus *“our PPE's are provided, and we have hospitals we go to in case of accident or when we fall sick. The contract we have is with Chevron and Chevron takes care of the trainings, but the company provides us with the necessary PPE's and other HSE materials to make us work safe”*. This comment suggest that this company values the health and safety of its workers and take safety as a priority by providing staffs with the necessary PPE's they need for the job and trainings. Speaking on the management level on this, the safety officer D2 stated thus *“for the company I work with, we know that health and safety is part of a construction business. We give it priority and we follow the procedures. If we are issuing out for example 20 PPE's per year, we do it. Safety boots, we provide the required ones. When I make my requisition on monthly basis, I include the safety devices we would need. The company flow with it. The company I work with don't have any stress about safety”*. This comment shows commitment to health and safety by this company. This commitment to safety has helped this company in having an accident free worksite as seen in the comment of D5: *“for companies working on the EGTL project, safety is never joked with. They provide us with trainings and PPE's, and they make sure we work safe. We have gone over 5 months on this project with zero incidents. If they were not strict with safety, workers will not obey. This is where accidents start from.*

#### **4.5.5. Management Actions and Inactions**

There are certain actions that management of companies can embark upon to ensure a good safety culture in organisations, which will ultimately lead to having safe work environment and safe work processes for their employees. Key among these actions is full commitment to health and safety. An absence of commitment to health and safety will lead to such construction organisations recording continuous series of accidents leading to injuries and death to their employees. How does management show this commitment?

The project manager D1 states thus: *“management need to provide finance, and management need to be responsible. They need to be example for others [...], if you are not committed, the workers will not be committed [....]. You are the to ensure that all policies are being followed,*

*and you yourself must follow them*". Finance is needed to drive safety in any organisation. Without finance, safety is zero. Money need to be spent to buy PPE's, to train workers, to put safety systems in place, for healthcare etc. Every organisation that are committed to safety are committed to spending money to finance safety. Speaking further, the D1 states: *"if you as a project manager goes to site, stay with your workers, watch them, encourage them, let them know that we all are a team, it makes them to know that they have a leader that believes in them, that believes in safety"*. This comment suggests the importance of social relationship within organisations. It goes a long way in making the social actors in organisations work well within themselves and the tools and techniques they work with. Managers are the ones that can lead this relationship. Showing commitment is showing leadership qualities with love and belief in your workforce.

Furthermore, participants also stated that training and awareness programs are important and as such management should provide this as evident in the comment of the safety officer. D2 states thus: *"management should make available, training and awareness programs, there should be a plan in place to make sure you keep talking to workers about their health and safety, this can be achieved through daily pep talk to basically keep reminding them of the importance of safety"*. The relevance of trainings and awareness to workers cannot be overemphasized. This is important particularly as it educates the workers on safe and unsafe work practices. Discussing about safety in daily pep talks before start of work reminds puts safety in the consciousness of workers as they go about their work during the day. Failure in these aspect by management leads towards one thing; poor health and safety culture, which invariably leads to accidents.

Participants also talked about provision of work tools and medicals stating that these should be provided by management as evident in the comment by participant D5: *"training of workers, providing the necessary PPE's for the jobs at all time, making sure that workers are all cared for medically. The most important is for management themselves to lead by example. [...]. Many of the accident that happen on site is because supervisors tend to rush workers. Many times, it is the supervisors that make workers break safety rules and work in unsafe manner. So, management has to let the safety start from them"*. The issue of supervisors focusing on work completion over any other thing concerning the job is one is one area that as participant state lead to many accidents on site. This comment by D5 suggests that management should investigate this issue and inculcate safety discipline in their supervisors.

Having stated all of these, are the management of this company committed to the health and safety of their employees? The answers to this are evident in the provision of training and PPE theme above. Also, participants stated that the company has a safety system in place that they make use of to ensure they always work safe. They also stated that before the start of any task, the company makes sure they go for hazard hunting and conduct job safety analysis. This is evident in the statement by D2: *“we have hazard hunt, we go out for hazard hunting, to look out for hazard and deal with them before we start work”*.

#### **4.5.6. 5S Methodology**

Participants in this company are not familiar with the lean 5S methodology tool and have no idea what the tool is about. However, a 5S video was played to them to explain what 5S is and how it works. After watching the video, participant stated that although they do housekeeping in the company and their housekeeping process is like the 5S, they however stated that the 5S tool is a very standard one. The safety officer D2 for example stated thus:

D2: *“it is a very standard housekeeping tool. Our normal slogan is ‘housekeeping is before, during and after the job’. It is a good process. It ensures that everything is in its place and you are ready to go for the days job”*. Speaking further, a labour staff D3 adds: *“the process is very good. We have almost the same kind of housekeeping process here. Not as detailed as this one in the video. We have stores where we store work materials and tools. When we want to work, we only take materials that we need for the job, and we clean the job site before, while we are working, and after we finish working. Housekeeping is the best form of safety in any construction site because it always helps to keep the site clean and tidy”*.

The goal of the 5S is to keep the worksite clean and free from hazards causing accidents. Speaking further on this tool the project manager D1 stated thus: *“a clean workplace is a safe place to work in. This tool is very comprehensive and the process from the first S to the last S, if followed can aside making the workplace accident free, also create a good safety culture for the company practising it.”*.

Participants stated that a lot of accidents that happen on site every day is because of the work environment not being clean and organised. They believe that proper housekeeping, which is what the 5S methodology is about can assist in eliminating the hazards that cause such

accidents and therefore improve safety as evidenced in the statement of the project manager D1: *“it will help eliminate accidents. A clean environment is one of the best forms of safety measures, and the 5S ensures that. So, yes it will help in eliminating accidents”*. Speaking on the accident elimination qualities of housekeeping, participants stated that it helps them to work and stay safe. They therefore believe that all that is needed is to give workers training and workers will work it. All participants stated that they will recommend the tool. Particularly, the safety officer D2 stated: *“I would recommend this tool because I think it is by far the cheapest systematic method to ensure order and safety if properly sustained”*.

#### **4.5.7. Visual Management**

The use of visual signs to warn people about danger zones in construction sites is important for accident prevention purposes. Participants in this company stated that they are familiar with the use of signs and that they use signage in their everyday job on site. Speaking on the importance of using signs, the project manager D1 stated thus:

D1: *“we use visual signs. They are very important, and it is also a way of communicating with the workforce apart from the pep talk, bulletins, etc. Signs are very good. I know they are attractive, colourful, it draws the attention of people in putting in some strategic places, and if you have something overhead, you put signs there, it tells you where to go to and where not to go to. Even on scaffold, when they tag scaffold, when the scaffold is no longer good for you to use, you put sign there, so, people will not climb it. Apart from barricades, you know sometimes people do not see barricades, they even walk through barricades, but when you put sign, they see that”*.

Furthermore, the safety officer D2 and other participants noted that because not all workers can read, they however will understand signs created with pictorials when they see them. D2 states: *“signs are the best. They are always the best because not all the workers can read, so, if you have a sign not just carrying the words, but some pictorials to ensure that the explanation is clear”*.

Stating an example of one of the signs they have on site, D2 continues: *If you take for instance, we have some signs on our pipe on our pipe racks, you don't need to ride your bicycle across the pipe rack because we have a lot of columns that can stand as barriers, so you might not see*



*that someone is coming you might easily just hit the person. So, those signs “do not ride a bicycle under the pipe rack” is written, now also there is a pictorial on the sign that shows a bicycle, a person on top of the bicycle, with the pipe sign. So, even if you do not know how to read, you will know through the pictorials on the sign that bicycles should not be ridden pass the pipe racks”.*

The relevance of training on the use of visual signs cannot be overemphasized. This is necessary so that workers, both those that can read and those that cannot read can understand what different signs represents when they see them on site, how they can be placed or positioned around the work environment to achieve their goal and the reasons they are being placed. Participant stated that they have been trained on the use of signage and they know how to place them. They all stated that the use of signage on site helps a lot in accident prevention and would therefore recommend the use of this tool.

#### **4.5.8. Problem Solving Framework (A3/PDCA)**

In this company, the A3/PDCA Problem Solving Framework have never been used, however, participants are aware of some elements of the PDCA contained in the A3 like the 5Why root cause analysis tool, which participants like the safety officer D2 and project manager D1 stated that they have used for root cause investigation. Participant stated that they like the structure of the A3/PDCA and its continuous improvement culture. For example, the safety officer D2 stated thus: *I like the flow it has, Plan, Do, Check, Act. It is very structured in its approach to problem solving. If you do this all the time, it will become a culture. Do you understand? and it will help with safety. We use 5Why for root cause investigation.* Something interesting about the Plan, Do, Check, Act (PDCA) circle is its ability to bring continuous small incremental changes in process, which can improve efficiency, quality, and safety. Participants believe that this ability makes the A3/PDCA a great tool not only for problem solving but also for continuous improvement. Participants stated that the A3/PDCA problem solving framework can help sustain the 5S and Visual Management. However, as stated by D3, that is if it is done in the right way. D3 states thus: *if it is properly done without cutting corners. If the 5S and VM is carried out as it should and becomes a part of the way the construction company approach safety, the A3/PDCA framework will even make it stronger as this will help with problem solving when problems arise”.* Asked if this tool can help continuously improve health and

safety on site, the project manager D1 stated thus: “Yes, it can help, because, I remember, one thing we do on training, we make the training compulsory, and we make it in such a way that you write exams. So, after the training, if you do not pass, that means you cannot continue working. But they give you option, if you train ones and do the exam and you fail, you will be given a second and third chance. After the third chance, if you fail, you have to leave the site. After the training, you are given an ID card to show that you have done and passed this training. So, it becomes a moral boosting thing to have the badge. I have done this training. You see workers with different ID’s that signifies the number of trainings they have done. Then some proof of doing a training are in the form of stickers, you see these stickers on helmets. So, when you are moving about the site, you see people with helmets having stickers, some with lots of stickers signifying the number of trainings they have taken. So, this all helps with continuously improving our safety system and when it now gets down to doing the job and there are problems, if we use a process like the A3/PDCA, we can solve the problems”. Participants all stated that they will recommend the tool, however as stated by D3: *Constant training is just what we need and little by little, improvements start coming up”*.

## 4.6. Case Study 5: Medium Scale Indigenous Company 2

### 4.6.1. Accident Examples

The essence of this theme is first to try to identify the types of accident mostly experienced by this company. Secondly, see how they align with the types of accidents listed by participants and those listed in chapter 2, and how similar or dissimilar they are to those experienced by other medium scale indigenous companies. Thirdly, if their causes can be traced to the three root causes by Abdelhamid & Evereth (2000).

The first accident example given here is by the company safety officer E2 about a fatal explosion accident. E2 narrates:

*“This was a case one of our workers who was an insulator, and some of the chemicals that he uses to carry out his assigned job or jobs. He discovered that there was a leakage in some of the in-storage containers containing different types of chemicals that are not supposed to mix. So, he was trying to turn the chemical in the leaking container into another, although I was not there when the accident happened, I was in the site office, but before the accident, we had seen him and asked him what he was trying to do, he said he is trying to separate the containers and see how he can clean up the area to avoid explosion, reason being that some of the containers are leaking and once they come in contact with others it can lead to explosion. So, at the process of doing it, we did not understand what happened but for the fact that there was an explosion. Two of the workers were killed in the process”.*

The second worker who died in the accident with the insulator was a field worker. Speaking on how the second worker became a victim, participant E3 a labour worker for the company stated:

*“The field worker was trying to help the company to save the chemicals, but he did not have experience about chemicals”.*

Asked what he thought could have caused the explosion, the safety officer E2 stated thus:

*“Two chemicals that were not supposed to mix together had met, and there was an explosion. [...]. If the chemicals did not come together, there will not have been an explosion that engulfed and killed the two of them”* Further, E2 stated: *“this was the most serious accident we have*

*had, and it was regrettable, and we are trying as much as possible to ensure that such thing does not repeat itself again”.*

Notes from this accident: Improper housekeeping, lack of, or not enough training of personnel on needed skills to work with chemicals, overconfidence that nothing will happen.

The second example given here is by the company project manager E1 about a crane boom falling on a worker. E1 narrates:

*“This one happened in our site in the Escravos Gas to Liquid Project. They were servicing a crane and the boom was boom out, they were working on the hydraulic system that was moving the boom in and out, so something happened that they had to go on break and the boom was out. So, all they had to do, was put it to the resting position, keep it safely before they go out for break. They left it there like that and there was no barricade or barrier around the place to tell onlookers, passers-by and most of the people who are working in that area that okay do not go there. That was how it was left. So, somebody went there, and sat under the shadow of the boom, because it was in the middle of the afternoon, taking a nap there. So, the boom now dropped on the person. He died instantly and that was how we lost that personnel”.*

Asked what he thinks contributed to this accident happening, E1 states thus:

*“I think one of the factors was that they don’t even have the basic knowledge of working under a suspended load. Since they saw that the crane was not carrying any load, they never thought that even the anchor itself can pose a risk to people”.*

Participant E4 also narrated an accident he witnessed.

*“The forklift we were using on the site then was bought by our company from another company and they said they carried out all checks on the forklift and certified it okay before bringing it down for us to work with. [.....]. You know forklift, anything pressurised, does not need a leakage, this forklift had a leakage, but they wanted to manage it. They turned excess hydraulic into the tank so that before it will finish leaking, they must have discharged the load. That was where problem came. As the forklift forked the load, lift it up, a worker was close to the forklift. That is another hazard, you do not go close to loads being lifted like that. While the forklift was going, the fork was dropping little by little, suddenly, it just dropped, and the load tilt out, fall off and hit the guy. That was the end of the guy”.*

Notes from these last two accidents: Lack of knowledge about suspended load (training) or oversight, failure to use visual signs and barricade around a hazardous work area.

#### **4.6.2. Reasons why Accidents Happen**

Participants in this company stated various reasons why accidents happen on site. The project manager E1 stated two reasons why accidents happen on site: *“One of them is knowledge: if the people that are going to do the job have no technical knowledge of the job; Risk assessment: People don’t have knowledge of risk assessment”*. Knowledge on the job is very important in construction safety hence the reason for training of workers on safety so they can be able to identify unsafe conditions on site and know the acts they perform that are unsafe. Hence in his response the safety officer for the company (E2) stated main reasons for accident as unsafe conditions and unsafe acts. E2 states: *“main reasons why accidents happen on site, this is broad, but am going to look at it in two angles. These are the unsafe condition, and the unsafe act. When we are talking about the unsafe condition, we mean the condition of a place capable of causing an incident in the worksite. When we talk of unsafe act, we are talking about the attitude of the workers towards the job”*. Unsafe conditions according to participants can arise due to defective designs of equipment resulting to failure of such equipment, and hazardous procedures due to lack of good procedures in place. Unsafe acts on the other hand can arise because of poor safety background, poor personal attitude towards safety, taking short cuts and not following procedures.

Other participant also stated that the mindset of workers when the task is on-going can also cause accident to happen. For example, E4 states thus: *“sometimes you can say accident happen due to mind set. What you are doing and where your thoughts are is different. Some reasons for this change in mindset during an on-going task according to participants can be because maybe a worker receives a bad phone call while at work, hence participant E3 stated thus “like now, they are trying to make sure that workers don’t use their phones during work and if they see anyone taking that risk, the person should be taken off the site because the incidents we have had from the past is given us lessons”*. Participants also stated that this absent mindedness can also result because of a worker not feeling fine and still being forced to work by supervisors.

Participants also stated that non provision of the right PPE's for workers and using the wrong tool for a job can also cause accidents.

### **4.6.3. Root Causes of Construction Accidents**

The essence of this theme is to highlight the root causes of accidents from participant's perspective. This is important because they work on sites and experience the accidents first-hand. Furthermore, their knowledge of the accidents and the root causes will play a very important role in creating a lean safety model that can mitigate the identified root causes. Giving very comprehensive points regarding accident root causes, the safety officer E2 stated thus:

*“One of the root causes of accident in the worksite is when hazards are not analysed critically, and the mitigation processes are not adequate. [...] For incident to occur, something must have contributed. It is either because you fail to recognise the hazard, or you fail to play your role as an individual. So, one of the root causes is hazard recognition.*

*Secondly, human failure, because you may be able to recognise the hazard, and all the process involved, but if you as a person, you don't implement it, it becomes a human failure, because if you see that this tool is defective, and you don't recognise it, and then you go ahead to use it, it becomes a human failure. The hazard was recognised, but you fail to eliminate it, and because you want to take a short cut. This are factors in root cause analysis”.*

This response from E2 points to these factors, not critically analysing hazards before the start of a task and therefore failing to recognize the hazard, recognizing the hazards, and continuing with the task without dealing with the hazards.

Participant E4's statement also goes in same line as stated above, however, E3 also states management inaction as a root cause. E3 states:

*“From my own perspective, I will say the root cause is not following the proper procedure, in the sense that, when you know that this is what is going to cause accident, you are supposed to put that thing in order. That is, you are supposed to take care of that thing that will cause the accident so that the accident will not happen. But if you overlook it that there is nothing there, nothing is going to happen, and then therefore diverting your mind from the hazard to other aspect of the job that you are doing, an accident will occur. So, I will say the root cause is*

*negligence on the part of the worker and even management in the sense that when management fail to take some action, it can lead to accident”.*

Other participants in this company have similar views about the root causes of accidents. For example. Participant E4 also states: *“first, you as the person carrying out the task, what did you look into, how did you access the job before starting, those are the key points. So, the root causes to me would be being unable to identify the hazards around you before you carry out the job, and this can be because you did not do a hazard hunt on the job location before you started the job, or you did but it was not thoroughly done. This covers all jobs apart from acts of God”.*

On his part the project manager E1 stated the following as the root causes of construction accidents. E1 states: *“the failure of regulatory body, the poverty, and the technical know-how, which have to do with training, the knowledge, these are the basic root causes of most accidents in the construction industry”.*

E5 talks about the root cause as being due to lack of housekeeping. E5 states thus: *On most accidents, sometimes workers might have followed all procedures, rules, and regulations, but one major issue is this; housekeeping when working. Because sometimes the cable that you lay on the ground that you are working with might later trip you and fall you, sometimes your tools or equipment on the ground that are not properly arranged or kept might somehow pose as danger to you. So, talking about root causes, after following the rules and regulations, housekeeping is one of the most essential because your work site must be clean. You need to clear walkway and the general work environment. They must be cleared so that injury or incidents would not occur”.*

This last statement by participant E5 is very important for accident elimination on site. Good housekeeping can eliminate sources of accidents in the worksite. However, training is needed to be able to identify root causes.

#### **4.6.4. Training and Provision of PPE’s**

An observation of workers in this company on site showed workers all kitted up in their PPE’s, some fully kitted and some partially kitted. Participants believe that some of the best ways a company can show commitment to safety is through provision of PPE’s and training of

employees on site safety. The safety officer E2 stated thus: *“you cannot show commitment without providing adequate PPE’s. You cannot say go and work and do the work safely when the equipment and safety gadgets to do the work safely are not there. So, the company must show commitment by providing these adequate PPE’s required for the jobs”*. Asked if PPE’s are provided for workers, E2 responds: *“yes. PPE's are provided always as at when due to all the workers. Even admin workers have PPE's because you are not allowed to even walk around on the site without your PPE's. Chevron is very strict about usage of PPE's on site so all sub-contractors must comply with that”*. Other participants also stated that PPE’s are provided for by the company. In this company, the safety standard regarding the use of PPE’s and safe work practice is very high. Checks are carried out while tasks are on-going to see if workers are complying to safety rules like the use of PPE’s. For example, participant E5 stated thus: *“there is a card we normally fill called the TSTO (Total Safety Task Observation) card. [...]. You use it when you go on the worksite to check how workers are carrying out their jobs, their PPE’s etc, if they are complying with the safety rules and regulations. We record all these down on the card, and if you see anything they are doing wrong, advice the workers, put them through on how to do it right, so that they can work safe and go back to their families as they came”*. This goes a long way in creating a safe work environment for workers. Participants therefore believe that provision of PPE’s and monitoring of workers on their use is important for accident prevention on site.

Regarding training, participants believe that to have an accident free work site, workers should be given regular training. They believe that a lot of hazards in the worksite that lead to accidents can be seen and taken care of before they become accidents if workers are regularly trained. Regarding training of employees in this company, the company safety officer E2 responds: *“We provide training for new workers before they are permitted to come on the site, and when workers are already on the site. If you look around, you will see different stickers on the helmet the workers have on their heads. Those stickers represent the different safety trainings they have attended on site provided by Chevron safety department”*. The company believes in training of workers on safety and hence make training mandatory for their workers. For example, participant E4 stated: *“Like this company I am with now, management are trying in terms of training because they made it mandatory that we must go for trainings whether you can read or not, you must go”*. However, training the workers alone does not prevent them from working in unsafe manners and thereby causing accidents, monitoring of the workers on site after to ensure that they understand what they have been trained for and are working



according to how they are trained to is important for total elimination of accidents. For example, participants stated that some employees believe because they have been doing the job for a long time, they know and understand the job, so based on this reason, they don't even give a listening ear during training and see no relevance of the training to them. These group of workers believe that accidents can never happen to them. However, this is one area where accident come up. Participants therefore stated that representatives from the safety department regularly walk around the site checking their compliance level to safe work practice and making sure workers are compliant.

#### **4.6.5. Management Actions and Inactions**

*“I always say for any company to have strong safety in their worksite, there must be a management commitment, if management are not committed to safety, there is no way they can drive safety in the workplace, if the management are not committed, even the safety manager will be frustrated. [...] because management will see you as a delay to the execution of the job”*. These was a statement from the safety officer (E2) for this company.

The actions and inactions of management towards safety is very important towards accident prevention in construction sites. For an organisation to have a good safety culture, management of such organisations have a lot of positive roles to play. An opposite of such roles would lead to disregard for the health and safety of personnel. One of such roles according to the project manager E1 is commitment to safety. E1 states: *“management should be committed; they should take safety as a priority in everything. One, by putting policy in place that will ensure safety compliance. Having the policy is not enough, they should make resources available to achieve that [.....]. Then, there should be commitment. Commitment driving it. The commitment can come in ways of “what do we do to encourage the personnel so that they can follow up?”*. Then, that will go towards getting incentives for the personnel's, if they can follow the procedures. There should also be discipline. [.....], they should lead by example”. The safety officer on his part believes that management role should mostly be towards monitoring of works done on site to ensure compliance with safety level. The safety officer is of the believe that most managements and organisations believe on paperwork's rather than in monitoring. E2 states thus: *“the role of management should mostly be in the issue of monitoring, because most management and organisations believe on paper works. So, when regulators come, we*

*just present the documents to them. So, management must be committed in ensuring that works done on site are monitored to the letter. [.....] take safety as a value, and they must be committed to ensure that the workers themselves know that management are committed".* Asked how this commitment can be shown to workers, the safety officer E2 stated the following: *"by providing adequate PPE's for workers, [...], by monitoring, and, re-enforcement through giving worker incentives, to increase their morals. [...]. It gives them sense of belonging".* Participants also believe that management should have good safety systems in place that workers can always work with to protect their health and safety. For example, in this company, participants stated that before they start any job, they carry out a risk assessment on the job through different safety tools like the PPHA, TSTI, and JSA. E2 states thus: *"when we have a job to do, we first go to the work area to assess the work, we call it site work inspection. We look at the nature of the job, what we want to do, how can we do it safely. We also have what we call PPHA (Phase Planning Hazard Analysis). If it becomes something that we cannot use only Job Safety Analysis (JSA), we now use PPHA. We now plan When we are doing PPHA, top management are involved because PPHA involves high risk jobs. So, management are now involved, to ensure that hazards are captured, all the safety measured, the equipment, whatever you need to have done to ensure that the job is done safely are managed at the process of planning stage, before the job is executed. These are the things we do".* As stated by E3 *"these are put in place so that we will do the work safely and go home safe".*

From the labour angle, participants stated that management should provide trainings and PPE's as well as periodic medical check-ups for workers. E4 states: *"management first must educate the workers, let the workers know that life is precious, if you lost it, that's all. Let workers go for medicals and be fit for the job. Management must always make sure workers have their PPE's, and the right tools to work with. They should also practice what they preach. By this I mean if they want workers to work safe and put safety first, they must also lead by example by putting safety first and take safety seriously, if not, workers will not obey".*

#### **4.6.6. 5S Methodology**

*"We have a rule for the 5S in safety, it's a housekeeping slogan, 'A Place for Everything and Everything in its Place'. Housekeeping is the main thing in safety. If the site is clean, there is*

*less risk and workers are less prone to accidents and incidents*". So stated the project manager E1 after watching the video of the 5S methodology.

When lean concept was first talked about with participants in this company, they stated that the concept was unknown to them. The 5S methodology was then mentioned to them, they also stated that they have never heard of the 5S methodology. However, a video of the 5S methodology in action was played to the participants and some explanations given by the researcher. After watching the video, participants stated that they do housekeeping and that the 5S methodology is like what they do. They however stated that the 5S methodology is more standard. For example, the project manager E1 stated thus: *"The 5S is similar to what we do on our site here but more comprehensive. The process or let me say steps of the 5S makes it a very standard method of housekeeping. [...]. You see risk management at play here"*. Speaking further on the similarity of the 5S methodology to the kind of housekeeping they do in the company, the safety officer E2 stated thus: *"we always say, a clean environment is a safe environment, because in our JSA on risk assessment, when we are talking about site inspection, we always say ensure your work environment is safe, we don't want trip and fall hazards, ensure the access to where you are working are okay. These are the first steps and at the end of the job we always say housekeeping. Ensure that you remove all the work material, all the hazards you generated, remove them, ensure the area is safe"*. The safety officer believes that without housekeeping, the work area will be unsafe and so housekeeping must be an integral part of the job they do on site. Speaking on the 5S methodology, E2 stated thus: *"it is a very powerful tool to enable workers to work safe in a clean and safe work environment. I was looking at the way the man was mopping the floor, trying to keep things safe, trying to tag tools, and how he was trying to clean the area that is slippery, how he was trying to keep the place clean, I think that shows the degree of awareness in trying to ensure workers are safe in the work site by taking the responsibility to clean. [...] Housekeeping is the key"*. Participants believe that having a clean work environment is good because it will help the workers to see any hazard that is around the site or that want to come up due to on-going task. From the view of the labour workers, E4 stated that *"the process of the 5S is a process one needs to look into before the start of any job, and if you can follow the 5S as it is in this video, you are safe at the end of your job. Because accidents like slip, trips and falls, falling object, it can take care of them. You see if you can identify the hazard, and then take care of it, the accident is prevented. Because the 5S focus on keeping the work environment clean, hazards are eliminated and hazards that come up during work can be easily spotted and eliminated"*. Going back to the

project manager, he believes that the 5S is well broken down to capture everything required in safety. He however stated that to keep the 5S as a standard, workers should be trained and well sensitized, and there should be a monitoring factor, sort of a KPI, key performance indicator to show that the workers are following the 5S procedures. All participants stated that they would recommend the tool. Participant E4 however stated that he sees some problems that can hinder the success of the 5S methodology in work sites saying: *“let me now behave as a supervisor right now. The supervisor does not want to see this 5S because they will see it as something that will slow down the job. All they think about is just production, production, production. They do not think about safety. Apart from supervisors, I am certain that there will also be some labour workers that will see the 5S as a big burden and would rather they go straight to the job”*. Asked if as a worker he would see doing the 5S as a burden, E4 responds: *“no. the process helps me work safe and I can go back home to my family safe. So, I will gladly do the 5S for my own safety. Remember I said the worker have 100% role to play in making the work environment clean because if an accident occurs, it is the worker that will die or get injured. I don't want to be injured, neither do I want to go to work and don't return”*.

#### **4.6.7. Visual Management**

Speaking on the use of visual signs to warn people about danger in the worksite, participants stated that the use of visual signs has helped a lot in preventing accidents on sites. For example, the project manager E1 stated thus: *“the number of accidents avoided on site daily using signs especially on big projects cannot be overemphasized. A lot of fatal accidents can happen on site and does happen on site because of lack of information about impending danger in certain areas where work is going on or work is on pause in the workplace. But with information, in this case visual signs in such locations, people are warned of the danger before walking into them. They see the signs and know immediately that this is a no-go area”*. Furthermore, E1 stated that *“visual signs are tools that are already in existence here in Nigeria. Although not everyone in construction companies use it, but it is widely used by many of the big companies around and even here in our company we make use of it a lot”*.

The safety officer sees visual sign as a communication tool. E2 states thus: *“I see it as what we call a means of communication because you are trying to communicate to persons about a particular danger in the worksite, and communication process is not something that you can*

*overemphasize*” Going further, E2 states that: “*when somebody cannot read and write, and he sees something written in the form of pictograms showing signs of different dangers and so on. They will see it and say yes, something is wrong here. Putting a barricade where you are doing a job is a means of communication because you cannot continue to talk “please there is a pit here, there is a pit here” but when you put a barricade, you have already communicated, telling persons to stay clear, there is danger here. We also have use of signs like “Men at Work” and you draw a picture of someone carrying out a job, which is a pictogram, people will know that workers are working there, and they don’t need to be there is they have no business there. Or somebody using a chemical, you cannot read and write, with the aid of the pictogram, you see the picture of a skull in the sign, the person walking by or close to who sees that sign will know that there is danger there. So, visual management is also a very vital tool for safety.* Participants stated that when they made use of visual signs in their work area it helped improve safety to a great extent and prevented accidents from happening. They stated visual signs create safety awareness on site by minimising exposure to injury and incidents.

One of the important things to put in place about the use of visual signs in the work site is training of employees on what each sign represents and how to place them in strategic places, especially for many companies that still do not make use of visual signs. The project manager E1 believe that it will be a big development to introduce the use of visual signs to such companies, but to however serve its purpose, E1 states that “*training is needed. You need to train personnel on what each sign means, when to use the signs, how to position the signs, the purpose for using the signs and all that*”. All the participants stated that they will recommend the use of visual signs in construction sites for accident prevention.

#### **4.6.8. Problem Solving Framework (A3/PDCA)**

Participants stated that they have never made use of this tools before, however, after watching the video of the A3/PDCA, they stated that it is a good framework that can help organisations with continuous improvement and problem solving. E1 for example stated thus: “*I think the process of the plan do check and act is such that one can continuously improve on a process, be it safety or otherwise. When one encounters a problem the Y5 in the A3 form comes into focus to find out the root cause of the problem. If we take this to safety and look at it very well, you will find out that it can improve on the 5S and visual management when done continuously*

*with proper consistent training of personnel. So, I think it is a good tool. It helps organisation to improve in every aspect of their work including safety. For an organisation using the 5S and VS, it can help them continuously improve on the system and make it a culture in the company”.*

One important aspect of the A3/PDCA framework is its ability to continuously improve processes, efficiency, quality, and safety through small incremental changes. Participants believe that these small incremental changes are good for safety. The safety officer E2 states thus: *One thing you must know is that changes and improvements don’t come in a rush, by getting those improvements gradually, even though slowly, you see that bit by bit, you constantly improve on whatever process you are doing. So, for solving problems involving safety this is good. Taking the PDCA to doing the 5S and VS continuously, workers becomes perfect in its use, the worksite becomes safer, and accident is reduced to the barest minimum”.*

Further, E5 a labour worker stated thus: *“the more we follow the process, the easier it becomes, and we understand it more, and it becomes a part of us. When it becomes a part of us, it becomes a culture that is incorporated in us that can positively influence and improve our health and safety”.*

However, to achieve its goal of problem solving and continuous improvements, participants stated that training is very important. E2 states thus: *“the training process in this is also important because managers have to be trained on how to use this framework to solve problems”.*

## 4.7. Case Study 6: Medium Scale Indigenous Company 3

### 4.7.1. Accident Examples

The essence of this theme is first to try to identify the types of accident mostly experienced by this company. Secondly, see how they align with the types of accidents listed by participants and those listed in chapter 2, and how similar or dissimilar they are to those experienced by other medium scale indigenous companies. Thirdly, if their causes can be traced to the three root causes by Abdelhamid & Evereth (2000).

The first accident example given here is by participant F5 about a fence that collapsed and fell on workers. F5 narrates:

*“when we were working at 2<sup>nd</sup> East Circular Road, there was a place we want to divert erosion from, during the excavation, there was a filling station fence nearby, of which they were supposed to bring down before we start work there. But they were managing it so that the company will not pay for the damage. So, they kept on managing it. After they excavate everything, they left. Then we have put on the base, as we were about to set the wall, we went to go and bring panel, before we came back, the fence collapsed. But safety supposed to be there to monitor it and know if that place is safe for us to work or not, but safety was not there. Safety did nothing, and the fence collapsed. We lost one of our workers there”.*

Speaking further on the dead worker, the project supervisor F1 stated: *“....., I discovered that the worker, company provided safety helmets for him, he refused to wear the helmet, that is what led to the death of that boy. Assuming he wore that helmet, he could have been alive today, nothing would have happened to him”.*

Could this accident have been avoided? The answer is “Yes”.

According to another participant that witnessed same accident F2, he stated that the Ministry of Works was informed before the excavation work was done and that the Ministry of Works came to do their own checks and put a peg on where the excavation should start from. F2 stated that the peg point was too close to the fence and the company told the Ministry of Works representatives that if they should excavate it at that point, the fence will collapse. However, in F2’s words: *“but they (Ministry of Works) insisted that we should go on like that, so at the end of the day, the fence collapsed”.*

This is now a case of “you identified the hazard, but you decided to still work around the hazard, and in an unsafe manner as well”. This is because of management failure and unsafe work practice.

The other accident example here is given by the project supervisor for the company F1: He narrates:

*“Like the other day, a slab fell on somebody’s leg, but we discovered that the fault is from the operator that lift the slab from the ground. He did not place the lifting cable well, so the cable now removed while lifting. The slab fell and hit the worker on the leg”.*

Participant F4 gave the last example:

*“There is one that happened when I was working in Ekenwa. Excavator machine should have a flag man, whereby there is no flag man, when the machine is turning, it might not really know what is at its back. So, I experienced this one where the excavator hit one of our workers in the process of turning. Then another one is most times we do not have safety shoes, due to this, some of our workers have stepped on nails and other sharp objects”*

These accidents are preventable accidents; however, the stories seem to suggest that in this company, things like trainings and PPE’s are seldomly provided for workers and safety is not given a priority.

#### **4.7.2. Reasons Why Accidents Happen**

In this company, participants stated various reasons why accidents happen. Participant F2 stated the following as reasons why accidents happen:

*F2: One is carelessness. I can only give example with where I am working. Like if you look at the nature of our work, it is a kind of job, in which you need to be very careful. I do not know if you saw the way we were transferring those panels when you came in, that thing being transferred is iron, not wood. It is iron panel. So, somebody has to be careful with the panels. I was there now when my supervisor called me. What I normally do every time is that I will have to stand there, maybe if that payloader is coming with the panel, I will tell those around to move away from within that place to avoid accidents because, somebody can just stand there looking but his mind is not there, maybe he is thinking of another thing, and if for instance a*



*panel falls off, it can fall on him or the payloader can even hit him. all these things cause accidents. So, I normally try my best to stand around when the payloader is bringing down the panels and warn people to go away from the spot. Negligence is also a cause of accidents. Also, unsafe worksite conditions can cause accidents. When tools are not used the right way, this can also cause accidents. Our attitude towards health and safety also can be a big factor. Then management not caring about safety is also a reason".* Furthermore, the project supervisor F1 stated thus: *"carelessness causes most of the accidents. Negligence and over confidence, lack of training, etc"*.

In one of the accident examples given in the types of accidents theme, the project supervisor was asked why some of the accidents listed were so common. His response was that it is due to carelessness of workers. Asked to expatiate what he means by carelessness, F1 stated thus: *"assuming that now you want to excavate, you know that in this area there is a fence very close to where you are going to excavate, you say let me try it, it will not happen, and it now happens that that wall falls down on the workers. This causes a big accident"*. F1 was talking about the excavation accident in the accident example where a fence close to the excavation point fell on workers and killed one of the workers. F1's comment suggest that the workers already know that it was dangerous to excavate close to the fence, yet they still went ahead. However, F1 should have realised he is the project supervisor and should have not given a go ahead to start the job. The singular action of giving the go ahead on that job also signifies carelessness from the part of the project supervisor and as such a management fault. Hence participant F5 stated that the start of all accidents emanates from management failure to put things in place to prevent such accidents. F5 states thus:

*"safety starts from the management. Before accident can happen, at least there are some certain things that must be put in place that have not been put in place. I told you like this place we are working; it is supposed to be barricaded to prevent accident. Like all these barricades are not here now, so prevention is better than cure. All safety materials and equipment are supposed to be here before we even start work. But so many managements don't care about safety so that creates avenue for more accidents to happen"*. Furthermore, F5 states thus: *"it can be because the worker is negligent, and his mind is not in the job. When we are working, and we do not concentrate, accident can happen. Some of us have problems at home, and when we are working, we are thinking of the problem. This will cause us to have accident too. But we try to always help ourselves work safe. It is a personal choice that we owe ourselves"*.

On his part, participant F3 stated that accident happen because of the unsafe work behaviour of workers, which arise because of lack of training. F3 states thus: *“most accidents are caused by human error through unsafe acts. There are some things that you are not supposed to do, but maybe because of the lack of knowledge on how to work safe on site, lack of safety trainings can lead to accidents”*. One of the major ways of preventing accidents is through training of workers on safe work practice. A failure to provide these trainings can result in unsafe work behaviours by workers, which can lead to accidents.

### **4.7.3. Root Causes of Construction Accidents**

Speaking about the root causes of construction accidents, the project supervisor F1 stated thus: *“lack of maintenance of machines for accidents that deal with machines. Another root cause would be knowing that an accident might happen in a situation and still carrying on with the job thinking that the accident will not happen just like the example I gave to you about the wall that fell”*. In the accident involving the wall that fell resulting in the death of a worker in the accident example theme, three root causes were identified by the researcher; knowing that the job was unsafe, commencing the job even though workers knew doing so was unsafe, and acting unsafe by not wearing the PPE provided. These acts can be traced to management failure on many angles, which include most importantly lack around training and monitoring. Hence participant F5 stated thus: *“sometimes the root cause is because the site management fail to do what they should do. You know that many times workers don’t even know what may cause accident when they see it”*. This statement by F5 brings about the reason why training is very important for construction employees. Without trainings, workers may never be able to identify what can cause accidents even when it lays right in front of them. Hence participant F2 stated that *“the root cause of accidents can be traced to lack of training”*. Participant F4 stated the root cause as: *To me the root causes are due to lack of safety orientation. A lot of us do not have the safety orientation to spot hazards. Because of this we see the hazards and still carry on working and then accidents happen. That is why it is good for companies to train workers.*

Furthermore, participant F3 stated the root cause of construction accidents as *“I will say human error is a major part, then when there is a failure in the provision of PPE’s and safety trainings by the employers, and failure of the maintenance of the tools or machine that you use in working”*. Most of these identified root causes all fall to management failure.

The theme on trainings and provision of PPE's will show to the readership if management in this company take the health and safety of their workers serious through provision of these.

#### **4.7.4. Training and Provision of PPE's**

A lot of things were observed not to be in place health and safety-wise in this company on getting to their site where a major road repair work was going on. Firstly, an observation of the workers in the company showed majority of the workers working with no safety boots on. Some of the workers had flip-flops on, some wore canvas that were as good as dead. One of the workers interviewed was wearing a sandal to work in a construction site. Only about three workers had rain boots on. Considering this is a road construction work, workers should always have reflective vests on. None of the workers had reflective vests on and none of the workers had helmets on. The job environment was very filled with so many hazards, and workers were working under these dangerous conditions unprotected. There was dust all over the place and workers had no nose covers on to protect them from the dust. There were a lot of places where barricades and signages were needed, only a few of these were seen. Workers were working with bare hands with no hand gloves. This site was an accident field for both workers and commuters walking through as the work was going. Health and safety in this company was poor and not given any priority.

The essence of training of workers on construction safety cannot be overemphasized. Participant F4 earlier stated that a lot of construction workers do not have the safety orientation to identify hazards. Therefore, due to this, they work around hazard without knowing they are hazards and accidents happen. Hence it is good for companies to train workers. Asked if they train their workers in this company, the project supervisor F1 responds: *"Yes, we train them before they come into the field"*. However, when other participants were asked the same question, the response was different. It seemed like the project supervisor was trying to promote the company image as a management staff. For example, participant F2 who is a labour worker stated thus: F2: *"No, the company does not provide us with trainings. We have never been trained on safety or anything"*. This comment was further validated by participant F4: He stated thus: *"we have not been put to training on safety courses, which we are supposed to be put into so as to be aware of safety hazards, and the do's and not to do's on the worksite"*. Participants however stated that they do have pep talks sometimes as stated by F5: *"we normally have pep*

*talk sometimes. But not all the time*". Other participants also stated that even the pep talk hardly takes place. They go straight to the job as soon as they get to site. Participants however stated that workers need to be educated on what hazards are and what constitute hazards, as this would help to stop accidents from happening on sites.

Regarding the use of PPE, one of the labour workers F5 stated: *When we started, there was no helmet, no reflecting jacket, most of the time, a car will be moving from far, at least if you put on reflective jacket it will show to the driver that someone is on the road working. But as it is now, we do not see reflective jackets, no helmets, no hard hats, no nothing, apart from the rain boot some of us are wearing now. Even when your hand gloves get lost to replace it becomes a big war. So, most of the time, you can see we work with our bare hands*". However, the project supervisor stated that workers are given PPE's. He also stated thus: *"you know that most of the PPE's we share here some of them are not original. We give a worker hand glove today, they tear tomorrow"*. The comment from other participants shows that even though the company provides some form of PPE's, these are provided occasionally and not to all the workers and they are substandard. For example, participant F4 stated thus: *"For instance, now, I do not have safety boot, only rain boot, and when the companies decide to share PPE's, they don't share complete. They might give just rain boots or safety boots, and that is it. In a construction site in which accidents varies, there are different types of safety materials that should be given like safety eye goggles, coverall, hand gloves, safety boots, hard hat, etc."*. This comment by F4 was further validated by participant F1. F1 states thus: *"they only gave us rain boots this year and that one is meant to be for if rain falls you can wear it and work in muddy environments and all that. But no safety boots. Normally, as we are working, we are supposed to have coverall, have helmets, wear safety boots, hand gloves, etc, but we are not provided with them and they expect us to work"*. As stated at the start of this theme, observation of the workers on site in this company showed many workers working with no level of PPE's on at all. One of the participants interviewed (F3) who said he works with the safety officer for the company had sandals on. When asked why he is not wearing a safety boot, he stated: *"my safety boot is bad"*.

Analysis of this company portrays a company with a very poor health and safety culture, the participants however stated that when the company worked on a contract with World Bank, they maintained a good safety culture and provided PPE's. Primarily because World Bank oversaw the project and supervised safety. For example, F3 stated thus: *"when we did erosion*

*control job in Ekenwa Road with the World Bank, at least the then consultant tried in the safety aspect because they actually emphasised on safety. They told our company that they do not want all these unsafe acts, accidents on the sites, etc. And the provision of the PPE's for the workers, they checkmate those things to see that everything is in place". F3 however believes that safety was given a priority in this case because it was a World Bank Project and they supervised it. F3 states "but I just believe that it is because it is from the World Bank that is why safety was looked into and supervised".*

This comment suggests that when indigenous construction companies work as contractors to multinational companies, they can be health and safety compliant, which also portrays that under strict supervision and monitoring, local indigenous companies be it small or medium can build a good safety culture. This is where the Nigerian government can play its role with health and safety regulations and enforcements.

#### **4.7.5. Management Action and Inactions**

It has been stated that the inactions and inactions of management have a big role to play in determining the health and safety culture within an organisation. If management have a positive attitude towards safety, health and safety performance would be good in such organisation. However, if the attitude towards safety is negative, then safety performance would be poor. In relation to this company, analysis so far suggest a negative attitude towards safety, which is a reason for the poor health and safety culture so far noticed from findings in this company. To start with, this is a medium scale indigenous road construction company with over 100 workers with just one safety officer who is hardly ever on site. As stated by participants, the company had no safety officer and only engaged the present safety officer because of a project the company had with World Bank. Participant F2 states: *"we had no safety before. The present safety officer was employed because of the world bank project. Because world bank are the ones that normally disturb. Like state work, and federal work, nobody cares about the safety of workers. Like that World Bank, before you start work, you must present all your safety equipment and plans. So, that is why they even employed the safety officer"*. It therefore means that from the onset of this company, safety has never been given a priority by the company and only became important during the World Bank Project. It would have been expected that the company will follow up with the good safety performance after the World Bank project but as

findings suggest, it is almost back zero. Participants believe that if management take certain actions, health and safety can be good in the company and accidents prevented. One of such positive actions is stated by F1 the project supervisor: *“if the management can always provide safety equipment for the workers including training and if management would take safety seriously themselves because if they don't take it serious then how can they expect workers to take it serious as well”*. F1 believes this would improve health and safety in the company and failure to do this would bring about accidents. Further, F2 believe that the owner of the company must take some action as well. He states thus: *“what I think is that, they should have people that will be going around to check workers to know if PPE's are given to them or not because I believe the owner of the company will not know that we do not have safety. So, if he has someone that will be going around to check and to look at the job and check workers whether they have safety equipment or not, I think they will improve on that aspect. As it is now, we have only one safety officer, and the safety officer as am talking to you now is not in Benin, he is in Auchi”*.

On his part, participant F3 believe another positive action that should be taken by management is to give proper attention to the HSE department. F3 states: *“I think the management should give proper attention to the HSE department, and the compliance of workers also, is also needed. Like some workers, you give them the PPE's and they will not wear it. They come up with different reasons for this. So, I think, the issue should be re-emphasized again and again during the pep talk, so that workers would understand the essence of putting on their PPE's”*. Further, F3 stated: *“management have a very big role. They must be the one to push HSE into the workers and they have to be strict with it”*. Anything less of this strictness according to F3 will lead to poor safety in the company.

Furthermore, participant F5 emphasized on the need for serious training of workers and provision of PPE's. F5 states: *“what I see here is that the safety personnel's and workers have to undergo serious training, and most of the companies I know, I see where the safety officers, like they fix a date, maybe Monday or Tuesday, they have a pep talk with the workers. So, from there what you as a worker don't know before, from the pep talks you can know the difference between safe and unsafe acts and through this you can know how to prevent yourselves from having accidents. Then provision of safety materials for workers.*

Participants concluded that the company should take a lesson from the world bank safety supervisory team and be strict and safety conscious as them to ensure good health and safety performance and accident prevention on site.

#### **4.7.6. 5S Methodology**

In this company, participants have never heard of the 5S methodology, however, participants stated that when the company had a project with World Bank, they did engage in some form of housekeeping. But presently in the company, they do not do any housekeeping. F4 states: *“we don’t do housekeeping here. It is straight to the job. The only thing we do is keep back our tools in the store after work for the day”*. The 5S is a housekeeping tool grounded in the principle of lean waste elimination. The video of the 5S in action was played to participants to elucidate what the tool is about and how the tool works to them. After watching the video, the project supervisor F1 stated thus: *“it is a very good tool. With the way it works, it can improve safety in Nigerian construction”*. Asked why he thinks this tool would improve safety, F1 stated: *“because a clean work site is very good. When a site is clean, it will be difficult to have accidents in that site. And if you look at the 5S, the way it is organised, if you follow the steps and do this every day on your work site, accidents will be reduced”*. Participants believe that a clean environment would make it easier to detect hazards that can cause accidents in the worksite and the 5S can create that clean environment. For example, participant F3 states thus: *“actually, it is a good system because once the environment you are working in is clean before you start work, I want to say you will be able to identify hazards that may cause injury or accidents. Those clean environments will help you to detect out whatever that is not supposed to be in the work environment Everything that will cause accident has been cleaned and because the site is clean, you can easily detect and remove hazards before it become accident”*. Speaking further on the accident prevention qualities of the 5S, another participant (F2) states: *”It can help a lot to prevent accidents on site because if you go around where we are working now, you will see many things scattered all over the place. At times you will even fall on some of them. Why, because we do not have all these ideas and no safety officer to bring these ideas. The only thing we know about safety here is just to control traffic. That is all. We don’t know or do anything about cleaning the work environment here”*

Furthermore, one of the labour workers emphasized on training on the use of the tool. Participant F5 states: “..... *One thing I always insist is on, is for proper training. If the safety personnel on ground undergoes a proper training on how to use this 5S and then come to train workers and also have pep talk with the workers on the use of this 5S before work starts on site, then it will help to clean the work site and prevent accident. This will improve the health and safety of workers. But if they do not train workers on this, it cannot work*”.

Participants also stated that they would be happy to do the 5S if the company introduces it. For example, F4 stated thus: “*Yes, I would be happy and am also sure the other workers will be happy to use it because it will help us work and stay safe*”. However, the project supervisor and the labour participants see a disadvantage to the success of the 5S on two opposite ends. The project supervisor F1 states: “*the only disadvantage I can see is some workers will see this as an extra job. They will even tell you their job is not to clean the site. If management do not encourage it and be strict about it too can be a disadvantage to its success*”. On the opposite end of this, one of the labour workers stated thus: “*the disadvantage will come mostly from the management side, especially the supervisors. They always hurry you up to complete the job. They will not give that time for workers to clean site before work*”. The labour participants however believe its use will depend on management as stated by F3 “*if they (management) say this is what we must do, workers will do it*”.

#### **4.7.7. Visual Management**

Participants in this company have knowledge about the use of visual signs in the workplace and does make use of it. Speaking on its use, one of the labour participants F2 stated thus: “*it is a good tool. Even if you cannot read, you can understand danger in a signpost when you see one. We use it here, and we use caution tape too*”. Expanding more on this statement, participant F5 states thus: “*if you go to many sites, a lot of labour workers are illiterates, they don't know how to read but when they see danger sign with picture of the danger, they understand it. Signs warn us of dangers on site*”. Participant F2 however, stated that some people still do not understand signs when they see one. F2 therefore advised thus: “*it is good that the company give workers training on why it is used and, also, they should draw images on the signs. That will make people understand it better*”. Training is very important to understand the use of signages. If workers are not trained on its use, as F2 stated, some will



still not understand why it placed where it is placed. Such persons can become the victim of the accident that the use of the signage is supposed to prevent. Regarding training of personnel on the use of signage in this company, the project supervisor F1 stated thus *“we have already trained them concerning it. They know that it is for their own safety”*. F1 however stated that the problem they have with its use has to do with commuters. F1 states: *“because we do road works, a lot of people walk through the road and some don’t know why the signs are there. If you tie a caution tape here now, in your presence you will see someone will just climb over it and cut the tape. Even though they see sign board with danger, a lot of them will not obey”*. All participants however stated that visual signages are good accident prevention tool. This can be seen in the comment of F5: *“it is a good accident prevention tool. A lot of companies use it. Even the company I worked with before I started with this company, they use it too, and it has proved to be good for preventing accidents”*

#### **4.7.8. Problem Solving Framework (A3/PDCA)**

In this company, participant stated that they have never made use of this tools before, however, after watching the video of the A3/PDCA, they stated that it is a good framework that can help organisations with continuous improvement and problem solving and therefore will help reduce accidents on site. For example, F1 stated thus: *“this tool can help in preventing more accident on site through investigation. Because when you investigate an accident and you know the root cause, you can use the root cause to correct that mistake, so it should not happen again. When you correct that, you have helped reduced accident”*. Furthermore, participants spoke on the need for proper training in making use of this tool. For example, F3 states: *“.... when we do something over a long period of time, that thing will now become part of us. If management can make use of this tool and give proper training to workers on the 5S and the visual management and on how the PDCA/A3 works, I am sure this will help companies to improve and to solve problems when they occur”*. One of the essences of this tool for the purpose of this research is about improving safety on site. Participants believe this tool will help in this aspect but also stated the need for management action. F5 states: *“it can help improve safety and problem solving if the management of the companies can do it and enforce it, because one thing is to have this process and the second thing is to make use of the process”*. Participants all stated that they will recommend this tool.

## **4.8. Cross Case Analysis**

In this section, the findings from the six case study companies are cross analysed to find similarities and dissimilarities. The cross analysis will be based on the main themes of the study, which are, the reasons for accidents, and root causes of accidents.

### **4.8.1. Reasons why Accidents Happen**

Parts of the reasons why accidents happen has been stated to be because workers are careless and, on many times, lose concentration while carrying out their task. This then results to unsafe behaviour by workers leading to accidents. Within the three small-scale indigenous companies (cases 1, 2, and 3) and medium scale indigenous companies (cases 4, 5 and 6) lack of concentration on the job, carelessness and negligence leading to unsafe acts by workers in the companies was identified. Another reason that has been attributed to why accidents happen is overconfidence on the parts of workers that no matter how unsafe they act on site; an accident can never happen. They have this belief that they because they have been doing the job for long time without having an accident, then it can never happen. However, they fail to realise that accidents are a respecter of no one. Accident has no friend and can happen majorly due to workers unchecked unsafe acts of carelessness. Across cases 1, 2 and 3, 4, 5 and 6, participants stated overconfidence on the part of workers as parts of the reasons that accidents happen. However, putting a check on such overconfident behaviour means eliminating negative behaviours from the heart and head of workers, which in most case is not easy, even with training. Hence negative behaviours and attitude towards safety by workers was listed as a root cause. Therefore, small-scale indigenous companies (cases 1, 2 and 3) and medium scale indigenous companies (cases 4, 5 and 6) unanimously agree these factors as reasons for accidents.

The above reasons have been identified to further occur as a result of management failure to provide trainings and necessary PPE's, which has been stated across small-scale companies (cases 1, 2, and 3) and medium scale companies (cases 4, 5 and 6) as another reason why accidents happen on site. Regarding training and provision of PPE's, in small-scale indigenous company 1, while the labour participants iterated that they were not given any training by the company, the management staffs stated that they provide trainings and PPE's but that workers would sometimes sell the PPE's given to them. However, a critical look at the accidents that

have happened in this company would suggest that the labour staffs were right when they stated that trainings and PPE's are never provided. Regarding PPE's however, as observed by the researcher when he visited the company site, some workers had PPE's on, while some had none on, which suggest that the company does provide PPE's but not all times. On the part of small-scale indigenous company 2, trainings and PPE's are never provided, participants stated that some of them have even had to buy PPE's for themselves to work safe and stay safe. However, in small-scale company 3 as observed first-hand by the researcher, trainings and PPE's are provided. Regarding the three medium companies, companies (cases 4 and 5) constantly provide trainings for their employees and necessary PPE's needed for the job are constantly provided too to all workers. In these two companies, workers cannot go on site without their PPE's on. That can lead to being sacked, so the safety culture in these company is very strong and positive. However, in medium scale company (case 6), the company does not provide trainings for its employees even though the project supervisor stated they do. PPE's are provided once in a blue moon and even at this it is just safety boots or rain boots that are provided and not for all workers. This is a road construction company that does not even provide reflective vests for its employees.

Small-scale indigenous company (case 3) stated failure to carry out a job hazard analysis or safety analysis before the start of the job as the reasons for accidents. This can be attributed to management failure or inaction to put necessary safety measures in place, which were stated by small-scale companies (cases 1 and 2) and reiterated in medium scale companies (cases 4, 5 and 6). When trainings are provided, PPE's are provided, safety management plans are in place to take care of and manage risk by a company management and there is commitment, then workers will always carry out job hazard analysis before the start of jobs. However, as findings suggest, small-scale companies (cases 1 and 2) fail in this aspect. But company 3 provide trainings and PPE's and have risk management plans in place to checkmate hazards. They make use of the Job Safety Analysis tool to analyse the risks in their jobs before the start of jobs. Medium scale companies (cases 4 and 5) provide constant trainings and necessary PPE's are provided. They also have risk management plans, which they make use of in analysing and identifying the risks involved in any task they embark on so that such risks can be avoided, and hazards eliminated. In medium scale company (case 6), findings suggest they just go site and work without risk assessment or risk management plans. The goal is job completion over anything else including safety.

In small-scale companies (cases 1 and 2), and medium scale company (case 6), workers complained about their work environment being dirty and filled with hazards and they work around these hazards hence in the accident examples given in these companies pierced by nails or sharp object accident, and object falling and hitting worker on ground floor were prevalent. Based on this reason, participant stated poor housekeeping and unsafe work conditions/environment as another reason why accidents happen across small-scale companies (cases 1, 2, and 3), and medium scale companies (cases 4, 5 and 6). To eliminate accidents like pierced by nails, and objects falling around and hitting works and others in the worksite, proper housekeeping need to be carried out before the start of a task, while the task is on-going and after the task ends. This also helps to take care of unsafe work environments. However, as findings would suggest, small-scale indigenous companies (cases 1 and 2) and medium scale company (case 6) does not embark on any housekeeping process and when they do, it is done by maybe a staff that has formerly worked with a big company who understands the relevance of housekeeping to his personal safety. However, in small-scale company (case 3) and medium scale companies (cases 4, and 5), they take housekeeping seriously and this is a core part of their jobs.

Machine failure was attributed as a reason for accidents in small-scale indigenous company (case 1) and in medium scale indigenous company (case 2). This failure arises from two angles as pointed out by participants. First from the machine itself and a result of faults in the machine and from humans because of incorrect use of the machine. However, other companies did not list this reason. Small-scale company (case 2) takes this forward by adding that some accidents happen because of faulty architectural designs. Small-scale company (case 3) and medium scale company (case 4) added that wrong mind set can also contribute to accidents. This arises when a worker's mind is in two or more places at the same time, which takes their concentration off the task at hand. Medium scale company (case 6) added that wrong use of tools and equipment can also result in accidents while drugs and alcohol use was stated by medium scale company (case 5). Natural disaster or act of God was also stated as a reason for accidents across small scale company (case 2) and medium scale companies (cases 4, 5 and 6). These are all highlighted in the table below.

*Table 6 Reasons for Accidents Cross Analysis*

<b>Reasons for Accidents.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
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Careless, overconfidence, and loss of concentration while carrying out their task. (Classed as human error) leading to unsafe behaviours.	✓	✓	✓	✓	✓	✓
Management failure to provide trainings and necessary PPE's including failure by workers to use PPE's.	✓	✓	✓	✓	✓	✓
Provide training?	?		✓	✓	✓	
Provide PPE's?	Partially.		✓	✓	✓	Partially.
Failure to carry out a job hazard analysis or safety analysis before the start of the job.	✓	✓	✓		✓	
Have risk management system?			✓	✓	✓	
Poor Housekeeping and unsafe work environment and conditions.	✓	✓	✓	✓	✓	✓
Do housekeeping?			✓	✓	✓	
Machine Failure.	✓			✓		
Faulty architectural design.		✓				
Wrong mindset			✓	✓		
Wrong use of tools and equipment.						✓
Drugs and alcohol usage.				✓		
Act of God/Natural Disaster.		✓		✓	✓	✓

#### 4.8.2. Root Causes of Construction Accidents

Within the small-scale indigenous companies, the root causes of construction accidents as explained by participants have some level of similarities. For example, lack of orientation about the job, failure to provide training, and lack of information and knowledge about the job were stated as one of the root causes by participants in small-scale indigenous companies 1, 2 and 3.

Although participants make use of different sentences in stating this, however, these three sentences point to knowledge about the job as being important to eliminating accidents and an absence of it can be a root cause. Therefore, lack of knowledge and orientation about the job is commonly accepted across all three small-scale indigenous companies (cases 1, 2 and 3) as a root cause. This root cause was also recognised by participants within all three medium scale indigenous companies (cases 4, 5 and 6). Therefore, the small-scale indigenous companies (cases 1, 2, 3) and medium scale indigenous companies (cases 4, 5, and 6) understand the reason why knowledge about the job is important for workers as this will make them understand the risks involved in the job and how to eliminate these risks. The primary knowledge can be gained through trainings, pep talks, etc. Within the three small scale cases and the three medium scale cases, findings suggest that even though these companies understand the importance of having knowledge about the job through training of workers, not all these companies (cases) provide these. For example, small-scale indigenous company 1 rarely provide trainings. Small scale indigenous company 2 does not provide any form of trainings for their workers. However, in small-scale indigenous company 3, trainings are frequently provided to give workers first-hand knowledge about the job, the risks involved in the job and how to eliminate these risks. On the part of the medium scale companies (cases 4, 5 and 6), case 4 and 5 companies provide training for their workers on regular bases. However, case 6 company does not provide any form of training. Although participants from the company stated that sometimes they do have pep talks.

Furthermore, small-scale indigenous companies (cases 1, 2 and 3) stated inability to identify hazards in the worksite before the start of the job as another root cause. Within the medium scale companies (cases 4, 5 and 6), this was also stated as a root cause. This suggest that all companies recognise this as a root cause. Recognising hazards in the worksite can be especially difficult for newly employed workers and old workers that have no training on safety hazards. However, aside from trainings given to workers, companies also need risk management plans that they can use to identify hazards before they become accidents. These plans can be in the form of using different hazard identification tools like job hazard identification forms (JSA), total safety task observation forms (TSTO), etc. Also, companies can embark on site hazard hunts and can introduce housekeeping programs to be done before the start of jobs to be able to identify hazards and eliminate them. Within small scale companies (cases 1, 2 and 3), only company 3 makes use of risk management plans. Company 3 conduct a risk assessment on their jobs and make use of the job safety analysis tool (JSA). Another way company 3 takes

care of their hazard is through housekeeping. Company 3 use housekeeping to keep their work environment clean thereby eliminating hazards and making un-eliminated hazards visible. Although in company 1 the project manager stated that they analyse the risks in their jobs before the start of the job, this they said led to them providing PPE's and use of barricades and caution tapes to prevent people from falling in trenches on one of their projects. This however does not hold ground especially with the accounts of the poor safety in this company given by participants. On the parts of the medium scale companies, case 4 and case 5 companies have risk management plans. These two companies are sub-contracting companies to major multinational oil companies in Nigeria like Chevron, Shell etc. These multinational companies do not joke with safety, so any sub-contracting firm working with them abide by their safety standards. For example, all sub-contractors working for Chevron must work with the safety systems provided by Chevron. Indigenous companies 1 and 2 (cases 4 and 5) at the time of this findings were Chevron sub-contractors working in Chevron projects. Case 4 and 5 companies make use of JSA's, TSTO's and other hazard identification tools to hunt for and eliminate hazards before the start of work. However, in case 6, a road construction firm, safety is not regarded, according to workers account, no job hazard analysis tools are used. Housekeeping is never done.

Identifying a hazard or unsafe condition and continuing with work without eliminating the unsafe condition was identified as another root cause. This was identified by participants in medium scale indigenous companies (cases 4, 5 and 6). In one of the accident examples given by participants in case 6 (medium scale indigenous company 3), participants stated that workers knew that if excavation job went on close to the fence of the gas station were the accident occurred, the fence would fall, however, even though this was discussed by management of the company and the workers, a decision was still taken for work to continue. The unsafe situation was not taken care of, and workers decided to work unsafe irrespective of the unsafe situation, which resulted in the fence collapsing, injuring some workers, and killing one. In cases 4 and 5, these companies will follow the right process to handle this job based on their commitment to safety and the level of risk management plans they operate with. Within the small-scale indigenous companies (cases 1, 2 and 3), this root cause was not stated.

Another root cause identified within these companies was management failure to provide a safe work environment for their workers. In the accident example theme in the previous section, workers gave examples of accidents they have been involved in. The accidents narratives given

by workers in companies 1 and 2 suggest that in these companies, workers work in unsafe environment. For example, narratives from company 1 had two instances where workers were pierced by nails because the work environment was unsafe, and the accident victims had no safety boots on. Another worker in company 1 fell on a stairway and broke his leg. Also, in this company, a worker died when a bucket fell off a crane on the workers head. All these show evidence that company 1 has failed to provide a safe work environment for its workers. The same story goes for company 2. The accident examples given in company 2 and some other responses given by respondents also suggest that there is management failure to provide a safe work environment in this company. This company does not carry out any form of risk analysis in their job sites. Workers constantly work in unsafe environments filled with hazards. However, in company 3, as seen in the previous paragraph, this company embark on risk analysis in every job they do and have methods of eliminating hazards from the work environments through their use of JSA's, housekeeping, etc, which help in providing a safe work environment for workers. The accident example given by the safety officer for the company suggested that it was unsafe work practice rather than unsafe work environment that resulted in one of the accidents narrated.

Further root causes were identified to be bad behavioural attitude towards safety by workers in small scale company 3. This can be attributed to carelessness of workers and overconfidence stated by participants in cases 1 and 2 and is identified by actions of workers as seen in the accident examples across companies 1, 2, and 3. Company 1 takes it forward by listing corruption on the part of government health and safety regulators as a root cause. Medium scale indigenous company 5 added poverty and failure by regulatory bodies as root causes.

Regarding the root causes of the accidents in the accident examples themes, in the small-scale indigenous companies, management staffs stated that investigations were done in the accident witnessed. However, labour participants across small-scale indigenous companies 1 and 2 stated that the accidents they were involved in or witnessed were not investigated to determine their root causes. Also, across small-scale indigenous companies 1 and 2, labour participants stated that when an accident happens, it is never investigated to find its root cause. This then brings a disparity in what to believe and who to believe between management and labour in these cases. The root causes stated by management is highlighted in the table below. However, in the accident example given by the safety officer for company 3, investigations were done to determine the root cause of the accidents. Participants in company 3 stated that they investigate



their accidents to find the root causes so lessons can be learnt, and such accidents do not repeat itself. Therefore, in companies 1 and 2, accidents are never investigated to find their root causes while in company 3 investigation is done to determine root causes. In the medium scale indigenous companies (cases 4, 5 and 6), cases 4 and 5 companies conduct investigations to find out the root causes of accidents when they happen. The accidents that happened in these cases were investigated and the root causes are stated in the table below. In medium scale indigenous company 3 (case 6), accidents are rarely investigated to find their root causes. In the case of the accident that ended with a worker losing his life, it was reported that the root cause was not investigated. However, in another accident in the company, the project manager stated that investigation was conducted. The root cause of that investigation is in the table below.

*Table 7 Accident Root Cause Cross Analysis*

<b>Root Cause of Construction Accidents.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Lack of orientation, information, and knowledge about the job. (Provision of Training)	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓
Inability to identify hazards in the worksite before the start of task. (Provision of Risk Management Plans)	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓
Identifying a hazard or unsafe condition and continuing with work without eliminating the hazard/unsafe condition.				✓	✓	✓
Failure to provide safe work environment. (Management Failure)	✓ ✓	✓ ✓	✓	✓	✓	✓ ✓
Negative behaviour and attitude towards safety by workers.	✓	✓	✓			
<b>Root Causes from Accident Examples.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>

Failure to pay full attention to the work environment by both the crane operator and the carpenter.			✓			
No job hazard analysis. There was no permit to work.			✓		✓	
Failure by the carpenter to do proper housekeeping after his task for the day resulting in nails on the floor, which the mason stepped on when he came to work the next day. (Failure to identify unsafe situation)	✓					
The worker was not concentrating on the task at hand.		✓		✓		
The worker took marijuana before work.				✓		
Two chemicals that were not supposed to meet, met resulting in the explosion.					✓	
Machine failure					✓	
Failure to identify unsafe situation/condition.				✓	✓	
The operator that lift the slab from the ground did not place the lifting cable well, so the cable now removed while lifting.						✓

### 4.8.3. 5S Methodology

Within the small-scale indigenous companies (cases 1, 2 and 3) and medium scale companies (cases 4, 5 and 6), none of these companies have made use of or are presently making use of the 5S methodology.

Being a housekeeping tool, the 5S helps keep the workplace clean and devoid of hazards through its systematic housekeeping process. Within the three small-scale indigenous companies (cases 1, 2 and 3), companies (cases 1 and 2) does not have an ongoing housekeeping practice. Small-scale company (case 1) does housekeeping at the start of the project where they sort out the site, which is a normal construction process. In company 2, one of the participants stated that he personally tries to do housekeeping where he is working. The reason for this is because when he worked with a big multinational company, housekeeping

was a practice in that company and as such has been built into him. He stated that they practiced a system like the 5S in the Chinese Multinational Company. However, housekeeping is not a practice in small-scale company (case 2). On its part, small-scale company (case 3) has a housekeeping practice, which the safety officer for the company tagged as “not okay and not as detailed and well set out like the 5S methodology”. However, they do housekeeping. Within the three medium scale indigenous companies (cases 4, 5 and 5), companies (cases 4 and 5) have an ongoing housekeeping practice. They do housekeeping before the start of tasks, while the task is ongoing and after the completion of the task. However, participants in these two cases stated that the 5S methodology is much more comprehensive than what they do. In medium scale company (case 6), housekeeping is not a practice. The normal practice is straight to the job irrespective of whether it is safe to or not.

In terms of the ability of the 5S tool to prevent accidents on site, participants from small-scale companies (cases 1, 2 and 3) all stated that the 5S methodology is a very good accident prevention tool that can help companies reduce and prevent accidents on site. The view was also shared by medium scale companies (cases 4, 5 and 6). In small-scale company (case 1), they believe the 5S makes jobs to be done in a more simplified way and that the process of carrying out the 5S methodology is not cumbersome. Small-scale company (case 2) believes the 5S methodology will help organisations to achieve a safer and more organized workplace where work will go smoothly, in low time, low cost and safely. A small-scale company (case 2) participant that worked previously with a Chinese Construction firm that made use of the 5S methodology for their housekeeping process stated that the use of the tool in the company helped reduce accidents and made their job quicker. Small-scale company (case 3) like case 2 believe that the 5S will make work more organized, easy, and fast in construction sites. Small-scale company (case 3) also believe that the use of the 5S will make construction sites free from obstructions. The safety officer in small scale company (case 3) stated that the 5S was used in a power plant he previously worked with and that process helped them improve safety in the power plant. In medium scale companies (cases 4, 5 and 6), medium scale company (case 4) believe that aside making the workplace clean, the 5S methodology can also create a good safety culture for companies practicing it. Medium scale company (case 5) believe the 5S methodology can help take care of such accidents like slip, trips and falls, hit by falling objects, and other accidents in the worksite. The company believes the 5S housekeeping tool is a risk management tool because the tool captures everything that is needed in safety. Medium scale

company (case 6) believe with the way the 5S methodology works, the tool will help improve safety in construction in Nigeria.

Small-scale indigenous companies (cases 1, 2, and 3) and medium scale indigenous companies (cases 4, 5 and 6) all are of the opinion that to make the 5S work, trainings must be provided for employees for them to understand how the 5S works and how to make use of the 5S. Regarding making use of this tool in the future, project managers and safety officer from small-scale companies (cases 1, 2, and 3) all stated that they will like to make use of the 5S. The project manager from small-scale indigenous company (case 1) stated that using the tool brings about accountability in the sense that with the proper arrangement of tools, you know when a particular tool is missing and when it's not missing, and that it will make his job to be done in a more simplified manner. In small scale company (case 2), the project manager stated that he will feel very happy running the 5S because it will save time, bring about low risk and low cost. He stated that he will research more on the 5S and see how he can implement same in the company. In small-scale company (case 3), the safety manager believes the 5S will reduce his stress of work, because everything will be in the right place. In the medium scale companies (cases 4, 5 and 6), they all stated that they would like to make use of the 5S if their organisations introduce it. In medium scale company (case 4), the project manager stated that if the tool is introduced into the system and they are trained, they can pass the training to their staffs because the 5S methodology is a procedure that need to be followed. In medium scale company (case 5), the project manager believes that the 5S is well broken down to capture everything concerning safety and so will like to make use of the tool for the safety of their workers. In medium scale company (case 6), workers had complained that their work environment is filled with so many things scattered all over the place that workers even sometimes fall on them. The workers believe the use of this tool in their worksite will help them work safe and stay safe. The project supervisor stated establishing it their worksite will be for their own safety and wellbeing.

All three small-scale indigenous companies (case 1, 2 and 3) and medium scale indigenous companies (cases 4, 5 and 6) recommended the use of this tool for accident prevention. Particularly, the safety officer for medium scale company (case 4) stated that he will recommend it because he feel it is by far the cheapest systematic method to ensure orderliness and safety if properly sustained. However, in small-scale company (case 1), the project supervisor saw a problem with sustaining the 5S process. Stating that it will be difficult to

sustain because the same management that approved it may still be the ones to fault in sustaining it because of poor safety culture. This fault is especially seen from the angle of supervisors rushing workers to complete their jobs rather than carrying out their housekeeping task before the start of jobs. This view was also shared by small-scale company (case 2) and medium scale companies (cases 5 and 6). Small-scale company (case 2) and medium scale company (case 6) however extends the problem of sustaining the 5S to not only management but workers also, stating that some workers may not be interested in cleaning before work because these workers feel housekeeping is not parts of the job. The table below shows a summary of these.

*Table 8 5S Cross Analysis*

<b>5S Methodology</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Company awareness and present use of 5S Methodology.						
Does housekeeping.			✓	✓	✓	
Prevention of Accidents.	✓	✓	✓	✓	✓	✓
Workers must be trained on use of 5S.	✓	✓	✓	✓	✓	✓
Future use of the 5S by companies.	✓	✓	✓	✓	✓	✓
Recommendation of the 5S in Nigerian construction.	✓	✓	✓	✓	✓	✓
<b>Problems that may arise using the 5S Methodology.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Management. Supervisors want job completion over any other thing and so they would not give workers time to do the 5S.	✓	✓			✓	✓
If there is no commitment by management, the use of the 5S will not work.					✓	
How many companies will be willing to spend or devote time to housekeeping? Big companies that are safety oriented, yes, but do not forget we have smaller companies that do not even look at safety. They just want				✓		

to do the job irrespective of whether the environment is clean or not.						
Labour. Some workers will see doing the 5S as an extra job, they will say it is not their job to clean the site.		✓				✓

#### 4.8.4. Visual management

Within the small-scale indigenous companies (cases 1, 2 and 3) and medium scale companies (cases 4, 5 and 6), all these companies have made use of and are presently making use of the visual tools for accident prevention in their worksites.

Visual management refers to the managerial strategy of consciously integrating visual tools in workspaces with the aim of increasing transparency in construction sites. In relation to safety it involves the use of visual tools to warn workers, visitors as well as passers-by about impending dangers and danger areas in the worksite. Within the three small-scale indigenous companies (cases 1, 2 and 3) and medium scale indigenous companies (cases 4, 5 and 6) there is evidence of the use of visual signs from observation of the work environment of the companies. Although not all companies had full use of them. Example in an observation of the worksite of small-scale companies (cases 1 and 2), the use of signs in these sites were very minimal. In medium scale company (case 6), even though there was the use of signs in some places in the work site, it was noticed that so many other places that would have benefitted from the use of signs were left without signages, thereby making such places a danger not only to the workers, but also to passers-by because this was a road extension job going on in a major road network and there were a lot of commuters walking through. However, in small scale company (case 3) and medium scale companies (cases 4 and 5) there were full presence of visual signages in and around the worksites warning people of various dangers in different zones. In the entrance to the Chevron project medium scale companies (cases 4 and 5) are working on, there is even a large visual signage with pictures of workers in their full PPE's, warning workers and visitors to not come into the site without their PPE's on.

Small-scale companies (cases 1, 2 and 3) and medium scale companies (cases 4, 5 and 6) all see signages as a means of communication to the extent that even people that cannot read

understand them when they see them. Small-scale company (case 3) stated that animations should always be made use of. Observations of the signages placed in these companies during the interview stage of this research showed that some of the signages in use had animations and were colourfully designed to capture the attention of workers, visitors. However, in some of the companies some of the animations were poorly designed. In small scale company (case 2) for example, the researcher saw a signage made, in which the words “DANGER” was not very visible. Some of the letters used in writing it were already cleaning off. One must go very close to the signage to know what is written on it. But in medium scale companies (cases 4 and 5), the signages were boldly written and could be read from a distance, the animations were well drawn to reflect what they warn about, and colourful. Same could be told of the signages observed in use in small-scale company (case 3). In medium scale company (case 6), some of the signages seen were also poorly designed. For example, the “men at work” signage seen had no pictorials of men working, which people that cannot read can see and understand. The words “men at work” was just written and placed in front of the barricade where the work starts from.

From the three small-scale indigenous companies and the three medium scale indigenous companies (cases 1, 2 3, 4,5 and 6), there is the consensus belief that the use of visual signs in these companies in the past and at present have helped to prevent accident in the work environment. Despite that not all the companies make full use of visual management, these companies all believe that visual signs are good for accident prevention on site and as such should be made use of in construction processes. Small-scale company (case 1) therefore suggested that construction firms in the country should be encouraged to use signages. Small-scale companies (cases 1 and 3) believe that using signs alone is not enough for accident prevention, as the project manager for small-scale company (case 3) stated, “for where we are now in this country, I don’t think the use of signs alone is enough for us, housekeeping first, then we have to pay attention to enlightening the workers”. These companies believe housekeeping should be done first, which is what the 5S the other tool to be combined with visual management tool is about, and then usage of signage. Overall, the importance of training is further highlighted.

To achieve its full benefit, both small scales companies and medium scale companies (cases 1, 2, 3, 4, 5 and 6) stated the need for training of workers on the use of these signages, what they mean and how to strategically place them. Small-scale company (case 3) extends the training aspect by stating that workers should also be educated on signages and what they mean during

pep talks and not just in the training classrooms. The company aside the classroom training, also uses the medium of pep talk to always speak to workers about the signages. Medium scale company (case 6) believes that if workers are not trained on the use of visual tools, some will not understand why they have been placed and such people can become victims of the accident companies are trying to prevent by using signages. However, there is no evidence to show that workers are trained on safety, and that also include the use of signages in this company as noticed from findings. In medium scale companies (cases 4 and 5), workers are regularly trained and every worker on site understand why signages have been placed in various locations, and the fact that only those permitted to work in such locations are allowed in.

Regarding recommendations of this tool for accident prevention in construction sites, small-scale companies (cases 1, 2 and 3) and medium scale companies (cases 4, 5 and 6) all recommend the use of this tool. The visual management cross-analysis table is shown below.

*Table 9 Visual Management Cross Analysis*

<b>Visual Management</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Company awareness and present use of visual tools.	✓	✓	✓	✓	✓	✓
The visual management tool can help with accident prevention in construction sites.	✓	✓	✓	✓	✓	✓
Training of workers is important for understanding how and when to use visual signs, what signs represents and how to place them strategically.	✓	✓	✓	✓	✓	✓
Provide Training?			✓	✓	✓	
Visual signs should be used along with good housekeeping.	✓		✓			
Recommendation for use in construction in Nigeria.	✓	✓	✓	✓	✓	✓

#### **4.8.5. Problem Solving Framework. (A3/PDCA)**

Within the small-scale indigenous companies and the medium scale indigenous companies (cases 1, 2, 3, 4, 5 and 6), none of the companies have made use of the A3/PDCA problem



solving framework. When problems arise in most of these companies, for example small-scale company (case 3) management just seat and discuss the problem and how to solve the problem. The company does not have a specific framework that they make use, however, regarding finding the root cause of accidents during investigations, the company makes use of the 5why root cause analysis tool, which is contained in the A3/PDCA form. Medium scale companies (cases 4, and 5) also stated they make use of the 5why root cause analysis within the company for root cause investigations. However, they stated that regarding the project they are working on at the time of the interview, when problems arise, Chevron Nigeria Limited investigation team handles the problem. They do not know what problem-solving tool Chevron makes use of, but both companies being subcontractors under Chevron stated that Chevron investigation team also make use of the 5why questions, an embodiment of the A3/PDCA.

Regarding the ability of this tool to solve problems in the workplace, small-scale companies (cases 1, 2 and 3) and medium scale companies (cases 4, 5 and 6) believe that the A3/PDCA tool can help organisations solve problems. For example, small-scale company (case 1) stated that the A3/PDCA can bring about efficiency in planning and this can help organisations to solve problems when they arise. Small-scale company (case 3) believe the tool will help organisations systematically solve problems in less time, without much effort. All three small-scale companies (cases 1, 2 and 3) and medium scale company (case 4) stated that the tool can be used to continuously improve work process creating a culture of continuous improvement. Medium scale company (case 5) believe this tool can combine with the 5S and visual management to solve problems that arise with using the 5S and visual management. While medium scale company (case 6) believe that if management of organisations can make use of this tool, it will help to improve health and safety in such organisations.

*Table 10 A3/PDCA Cross Analysis*

<b>Problem Solving Framework (A3/PDCA)</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Company awareness of A3/PDCA.						
Make use of 5Y for root cause investigation.			✓	✓	✓	
Tool can help with problem solving in organisations.	✓	✓	✓	✓	✓	✓
Tool can continuously improve work process creating a continuous improvement culture.	✓	✓	✓	✓	✓	✓

Tool can help organisations trace root cause of problems and provide counter measures thereby helping solve health and safety issues on site.	✓	✓	✓	✓	✓	✓
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#### 4.9. Chapter Summary

This chapter presented an analysis of the data collected from the six case-study companies that participated in the research. The chapter started with the profile of the six companies that make up the case-studies for the research. Following this, six in-depth case studies was then conducted, and a cross-case analysis was carried out to compare, and contrast findings from all the cases. Through this, five main root causes of accidents in the Nigerian construction industry were identified: (i) lack of information, knowledge, and training; (ii) inability to identify or recognise hazards/unsafe conditions in the worksite before the start of tasks; (iii) identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition; (iv) management failure to provide safe work environment; and (v) negative behaviour and attitude towards safety by workers. Furthermore, it was also found that the 5S methodology, visual management and the A3/PDCA can be implemented in a safety system to mitigate accident root causes.

The next chapter will therefore explain, discuss, and interpret the results found in this chapter in line with the literature with the aim of developing a Lean Safety Framework that construction firms can use in improving safety performance.

## **5. Chapter Five – Discussion**

The aim of this chapter is to discuss the result from the qualitative case study conducted for this research. The discussions will be carried out in three main sections based on the three objectives, which were set out for the study, namely: investigate the root causes of accidents in the Nigerian Construction Industry; explore how and to what extent lean tools such as the 5S methodology, Visual Management and the A3/PDCA problem solving framework can be used to mitigate these root causes; and to develop a conceptual lean framework to allow organisations to diagnose and improve health and safety performance. These objectives and the findings therein will be discussed and bridged with evidence from previous studies as depicted in literature to help to answer the research question: How can the adoption of lean practices be applied in a safety system to mitigate accident root causes in the Nigerian Construction Industry?

### **5.1. The Root Causes of Accidents in the Nigerian Construction Industry**

In the findings from this study as highlighted in the chapter 4 of the thesis, five main root causes were discovered to be the root causes of accidents in the Nigerian construction industry based on analysis of the data from the six case study companies. The five main root causes identified were: lack of safety orientation, information and knowledge about the job, which will be classed as lack of training; inability to identify hazards in the worksite before the start of tasks; identifying hazards/unsafe conditions and continuing with work without first eliminating the hazard/unsafe conditions; failure by management to provide a safe work environment, and negative behaviour and attitude towards safety by workers. These root causes will form the basis of this discussion.

#### **5.1.1. Lack of information, knowledge, and training**

Because of the many dangers present in construction jobs, it is paramount that when workers are employed to work in this sector, these workers are trained appropriately. The importance of giving regular safety trainings cannot be overemphasized as it above all saves the lives of workers from the dangers inherent in construction sites daily. Therefore, not offering training to employees or poorly training employees before taking them on the job and sending them

straight to site can be very dangerous not only to the newly employed workers themselves, but also to the entire workforce in such sites. As stated by Toole (2002), an untrained worker may not be able to identify and avoid all potential hazards that are part of the tasks he or she is performing. However, if workers are well trained and have an awareness of the hazards around them, these training and awareness can help them to protect themselves and their co-workers from the various dangers inherent in construction sites and therefore from injury and even death (Cutforth, 2012). The findings from this study suggest that many indigenous construction firms in Nigeria do not provide training for their employees before sending them to site to undertake various tasks. The few indigenous companies that provide trainings are the very few among many who give safety a priority based on the background of the company owner. Example, the case of small-scale indigenous company case 3 whose company owners construction background is from England, and those that are sub-contractors to multinational firms. Example, medium scale indigenous companies' cases 4 and 5 who are sub-contractors to Chevron Nigeria Limited. Chevron provide and conduct the training for staff of these indigenous firms as noticed in medium scale cases 4 and 5 in the findings section of chapter 4. This is in line with what was stated by Oluase (2014) that in a typical Nigerian construction company, more than 70% of Nigerian workers do not receive safety training. Safety training within construction firms should be an ongoing process with which to engage workers so that constantly, these workers can learn how to protect themselves and others working with them. Training as revealed by Chouldhry & Fang (2008) enables a worker to acquire the skills needed to safely perform a task.

Furthermore, a lack of safety training for newly employed workers and a lack of regular safety training for already employed construction workers have severally been attributed to be a root cause of construction accidents (Toole, 2002; Cheng et al. 2010; Chouldhry & Fang, 2008; Goh et al, 2016). Workers can receive training accordingly to overcome majority of the hazards. These hazards include but are not limited to slip, trips and fall hazards, hit by falling object hazards, electrical hazards, pierced by nails or sharp object hazards, scaffolding hazards, trenches and excavation hazards, work from height hazards, power tool use hazards, moving vehicle hazards, signage hazards, machinery and equipment hazards, non-use and wrong use of PPE hazards, etc. To buttress this point further, the case of a worker who has not been trained on signages placed in and around the site is considered. When such worker has not been trained, the worker is unaware of what such signages are and mean when he/she come across them on site. Rather than prevent the worker from the hazards and dangers the signs warn about, the

worker would much likely ignore the signage and walk into the hazard/danger and become an accident victim. Same goes with the proper use of personal protective equipment (PPE's) on site. When workers are provided PPE's without training, they will most likely not get the full safety benefit of its use and therefore use the PPE's improperly. Same goes for tools and equipment and safety systems. The list goes on.

Being a sociotechnical environment, the construction worksite is a place where people (the social bundle of the work environment) make use of various machines, tools, safety systems, etc (the technical bundle of the work environment) to execute their everyday job. In every sociotechnical system, to create a balance, the social bundle and the technical bundle must be at par with each other and work harmoniously. Therefore, to have a safe worksite, one of the important requirements is to educate the social bundle (workers) on how they can work safe with the tools and equipment, and safety systems to be used for the job execution. According to Carayon et al. (2015), training is a component of socio-organisational context that can impact work systems. The transformation of such safety training to actual skills and knowledge used by workers shows an example of the interfaces between socio-organisational context and work systems (Carayon et al., 2015). Thus Kadiri et al. (2014) stated that adequate training must be provided to create awareness about safety to all construction site workers. It is the duty of company management to provide these trainings to employees so that they are aware of the hazards around the worksites, how they emerge or can emerge, and what they can do to eliminate these hazards should they be identified before the start of the tasks, or while the task is ongoing. This can help provide a joint optimization of the social part of the work system (humans) and the technical part, which are the work tools and techniques according to the tenets of sociotechnical systems.

In one of the ten axioms of industrial safety put out by Heinrich (1931), it was stated that management should assume responsibility for safety. Ridley (1986) stated that unsafe acts of workers and unsafe conditions result in 99% of accidents in construction. Heinrich (1931) stated that 88% are caused by unsafe act of workers. Agreeing with this, Choudhry & Fang (2008) stated that majority of accidents are connected to more of unsafe acts of workers. Heinrich (1931) in his Domino theory therefore suggested that to stop accidents from happening, the direct cause of accidents, which is unsafe acts should be taken off his domino sequence. Bird & Loftus (1976) updated the Domino Theory and placed the power and authority to prevent the direct cause of accidents on management. They have the direct

responsibility for health and safety of employees. Part of these responsibilities is to provide training for workers so that they can act safe rather than act unsafe. The main difference between safe workers and those who frequently get hurt is that the safe workers can recognize hazards and actions that are hazardous including the consequences. Therefore, if management provide proper training for workers, unsafe acts can be prevented and thus the primary source of accidents eliminated. This is because safety training provides the means, by which accidents can be made more predictable (Vredenburg, 2002).

In the Nigerian construction industry, findings reveal that the management of majority of the indigenous construction companies do not pay sufficient attention to health and safety issues. This research found that many of the workers who work for these indigenous companies are taken on the job based on “daily pay” or “finish and go” basis with no prior knowledge about the job and no training provided for them and many of those that employ workers on long term basis still do not provide training or when they provide, it is inadequate. Few of the participants that have had one safety training or the other stated that they got their training when they worked with multinational companies and not from the present company they are with. Due to this lack of training, they do not possess necessary knowledge about the jobs they are employed to undertake, and the risks involved in the jobs. Consequently, while working, they get involved in accidents leading to injury and even death. The findings from this study therefore reveal that lack of information, orientation, and knowledge about the job, which is summed up as lack of training is a root cause of construction accidents in the Nigerian construction industry. This finding is in line with previous studies from (Cheng et al. 2010; Chouldhry & Fang, 2008; Brace et al., 2009; Masood et al., 2014; Goh et al, 2016; Muktari & Chinyio, 2016), which identified lack of training as a root cause of construction accidents. However, while previous findings show that workers are trained but inadequately hence, they get involved in accidents, this present research found that in the Nigerian construction industry, majority of the indigenous companies do not offer any form of training at all to their workers both before they are taken to site to work and even while they are working. This makes the accident situation resulting from this lack of training even worse.

### **5.1.2. Inability to identify or recognize hazards/unsafe conditions in the worksite before the start of task**

The inability to identify or recognise hazards or unsafe conditions before the start of work can be a big problem because of the various level of hazards in and around the worksites that if not recognised can lead to accidents. The hazards include slips, trips, and falls hazards, falling object hazards, moving object hazards, work at height hazards, electrocution hazards, collapse hazards, moving vehicle hazards, chemical explosion hazards to mention but a few. These hazards present risks that if not identified and eliminated or controlled before the start of tasks and during tasks when they arise could lead to the risk of falling victim to a fatal or non-fatal accident resulting to injuries and even death of workers.

The present research found “the inability of workers to identify or recognize hazards/unsafe conditions in the worksite before the start of task” as one of the root causes of accidents in the Nigerian construction industry. In the literature review chapter of this work, it was revealed in the study by Abdelhamid & Evereth (2000) that accidents occur due to three root causes. The first of the three root causes identified by authors was failure to identify an unsafe condition that existed before or after an activity was started. Unsafe conditions are classed as hazards that were unidentified at the start of the jobs. This finding is therefore in line with previous studies from (Abdelhamid & Evereth, 2000; Chouldhry & Fang, 2008). Furthermore, there are factors that contribute towards the inability of worker to be able to identify hazards before the start of each job. Chief among these factors are the role of management in terms of commitment to safety. The actions and inactions of management. For example, failure by management to have risk management plans, failure to train workers on safety and how to identify safe and unsafe conditions and hazards, and failure to commit to safety.

Further findings from the present research suggest that the reasons for this inability to identify hazards and unsafe conditions centre on most indigenous companies in the country not making use of adequate risk management plans that can help identify and eliminate hazards before they lead to accidents on site. However, the application of risk management plans helps construction practitioners with effectively managing risks on site. When hazard analysis is carried out on site before the start of tasks, different types of hazards can be identified and thus the risk they present can be eliminated or controlled before they result into accidents. Of the three small scale indigenous construction firms that participated in this research, it was discovered that

only small-scale company 3 could boast of having safety management plans. According to the safety officer, before the commencement of any project, risk assessment is done and before any task is started, a job safety analysis (JSA) is done to identify all likely sources of potential hazards. Also, where work permit is needed, it is followed appropriately, and workers are trained on the use of these tools. Same cannot be said of the other two small-scale construction companies. Labour participants in small-scale companies 1 and 2 all spoke about how their work environment are dirty and filled with hazards and how they must work around the hazards without control measures. These indigenous companies do not have any practicable means of hazard identification coupled with supervisors focusing on job completion over safety, workers are rushed. Therefore, accidents are frequently experienced by workers. Medium scale indigenous companies 1 and 2 are sub-contractors in a Chevron Nigeria Limited project. The companies work with the Chevron safety management templates and make use of various hazard identification tools such as the JSA, TSTI, TSTO, Work permit systems, Phase Planning Hazard Analysis (PPHA). Participants in these companies stated that the use of these tools help them to identify hazards and work safe. However, in medium scale company 3, no such tools are used. It is straight to the job. Supervisors in this company are more interested on task completion and so no time is spent on hazard analysis.

The implication of this for these indigenous companies without safety management plans is that due to this lack of safety management plans, workers will not be able to identify potential hazards. Especially taking into consideration the findings from this study that the work environment in many of these companies are filled with dirty, unorganised, and unsafe to work in. This makes the potential for the hazards and unsafe conditions in the work environment leading to accident to be on the critically high side. Some of the best ways to make workers identify the hazards and unsafe conditions around them in work environments like these deals with job training as highlighted in section 5.1.1, and as has been highlighted in previous paragraphs of the section, provision of safety management systems. Unfortunately, aside from medium scales companies 1 and 2 who are Chevron contractors, working with Chevron safety management systems and small-scale company 3. It can be deduced as found in this study that in majority of the indigenous companies in the country, a lot of accidents occur due to this inability to identify hazards/unsafe conditions before the start of work. Therefore, it is advised for management of indigenous firms in the country to invest in safety management systems. By doing this, majority of the hazards that result in accidents can be identified by workers



before they emerge and therefore prevented. This will help in taking care of the sociotechnical system of the work environment.

### **5.1.3. Identifying hazards/unsafe conditions and continuing with work without first eliminating the hazard/unsafe condition**

As this research has found, many of the construction sites of indigenous firms in the country fall under this category of being unsafe to work in because of the dirty, unorganised state of the work environment. Thus, the work environments are characterised by various hazards including those being generated as work progresses. Normally, when a hazard or unsafe condition presents itself in the worksite before or develop during a task, the worker either succeeds in identifying the unsafe condition/hazard or fail to identify it. When such unsafe conditions or hazards are identified, the normal thing to do is to first inform the supervisor or safety officer, then the team evaluates the risk and depending on the level of the risk, work must stop first for the hazard or unsafe conditions to be eliminated or controlled before work starts again. However, this present research found that sometimes workers identify these unsafe conditions, but they continue to work without first doing anything to eliminate the unsafe conditions/hazards thus accidents occur. This is in line with findings by Abdelhamid & Evereth (2000). The study also found that supervisors in these companies have the habit of always rushing workers to complete task. Therefore, when workers identify unsafe conditions as they carry out their task, they do not inform their supervisors, knowing fully well supervisors are only interested in job completion and meeting of deadlines. Rather, they just continue with the tasks irrespective of the identified unsafe condition/hazards thereby “taking chance”.

Aside from supervisor’s rush to complete task, several other reasons could accrue for why workers continue with tasks after identifying unsafe conditions/hazards. The present research found that management of some indigenous construction companies in the country do not care about health and safety. Therefore, they are not concerned about hazards. Psychologically, workers can go with same attitude by accepting the unsafe conditions and hazards as part of the job characteristics and thus continue with work without first correcting the unsafe situation. Overconfidence by workers can also be another factor because of the belief they can work around the identified hazards without being involved in accidents. Another reason for this can

be due to influence of drugs and alcohol, which this study found to cause accidents, see section 4.5.1. Brain overload could also be a factor for this.

Sometimes when workers identify unsafe conditions/hazards while carrying out their tasks, they try to correct the unsafe conditions. However, because of lack of knowledge and not following proper safety procedures they end up being accident victims in the process. The accident case narrated by the safety officer (E2) for medium scale company 5 as highlighted in section 4.6.1. points in this direction.

“This was a case one of our workers who was an insulator, and some of the chemicals that he uses to carry out his assigned job or jobs. He discovered that there was a leakage in some of the in-storage containers containing different types of chemicals that are not supposed to mix. So, he was trying to turn the chemical in the leaking container into another. Although I was not there when the accident happened, I was in the site office, but before the accident, we had seen him and asked him what he was trying to do, he said he is trying to separate the containers and see how he can clean up the area to avoid explosion, reason being that some of the containers are leaking and once they come in contact with others it can lead to explosion. So, at the process of doing it, we did not understand what happened but for the fact that there was an explosion. Two of the workers were killed in the process”.

Asked what he thought could have caused the explosion, the safety officer E2 stated thus:

“Two chemicals that were not supposed to mix together had met, and there was an explosion”

The safety officer reported that the normal process is that when dealing with such chemicals, you must be authorised by the management, and when you see such thing as chemicals leaking from containers, you must report it and you must obtain a permit. But he stated that for this incident, there was no permit process made by the workers. The workers did not report the unsafe condition after they identified it, and nobody authorised them to do the job. Although in this instance the workers tried to take care of the unsafe condition, however, they did not follow the safety procedure for doing this and so there was an explosion, which led to the death of two workers on the site. One of the factors that can trigger an unsafe condition to becoming an accident is by not following safety procedures (Udo et al., 2016). In this case, as explained by the safety officer for the company, both workers did not follow procedures in dealing with the identified unsafe condition, which was said to be the root cause of this accident.

In another example, one of the labour workers for medium scale company 3 (case study 6) in chapter 4 section 4.7.1. reported thus “when we were working at 2<sup>nd</sup> East Circular Road, there was a place we want to divert erosion from, during the excavation, there was a filling station fence nearby, of which they were supposed to bring down before we start work there. But they were managing it so that the company will not pay for the damage. So, they kept on managing it. After they excavate everything, they left. Then we have put on the base, as we were about to set the wall, we went to go and bring panel, before we came back, the fence collapsed. We lost one of our workers there”.

According to another labour worker that witnessed same accident, he stated that the Ministry of Works was informed before the excavation work was done and that the Ministry of Works came to do their own checks and put a peg on where the excavation should start from. F2 stated that the peg point was too close to the fence and they told the Ministry of Works representatives that if they should excavate it at that point, the fence will collapse. However, in F2’s words: “but they (Ministry of Works) insisted that we should go on like that, so at the end of the day, the fence collapsed”. Clearly, the unsafe condition was identified in this case, the company management knew of the unsafe condition, and still allowed their workers to work around the “unsafe condition”, which led to the death of the worker and many others that sustained fatal injuries.

According to Abdelhamid & Evereth (2000), unsafe conditions happen due to one of four causes: the actions and inactions of management; unsafe acts of worker or co-worker; nonhuman related events; and unsafe conditions that are natural part of the initial site conditions. In the case of the first accident reported herein, the safety officer did state that they had seen the workers undertaking the task before the explosion and had asked them what they were doing. However, as a safety officer, he did not perform his function. He did not ask the workers for the work permit to do the job. He did not ask them for the job safety analysis (JSA) for the job. He did not give a stop work order, which was what he could have done until the right procedures are followed. The direct and proximate causes chart by Heinrich (1931) pointed out that management have the power and authority to prevent accidents. After providing everything that will make a worker work safe, management still need to take their proactiveness to the field and look out for unsafe acts and correct them. It is the duty of the safety officer to do this. However, as noticed in this accident, the inaction of the safety officer also contributed to the accident happening. Both accidents could have been prevented if the

supervisor for the first accident stated here and the safety officer for the second accident performed their functions rightly. This showed management inaction as stated by Abdelhamid & Everett (2000).

The finding from this study is in line with findings from previous studies that identifying hazards/unsafe conditions and continuing with work without first eliminating the hazard/unsafe conditions is a root cause of construction accidents (Abdelhamid & Everett, 2000; Chouldhry & Fang, 2008; Cheng et al., 2010). However, findings from this study also suggest lack of knowledge of the impact the identified unsafe conditions could cause as a core reason why workers continuing with work even after identifying unsafe conditions without first taking care of the conditions.

#### **5.1.4. Management Failure to provide a safe work environment**

The actions or inactions of management in any organisation can have a positive or negative effect on the overall performance of that organisation including in health and safety. Regarding health and safety, it is the duty of employers to provide a safe work environment for their employees. Therefore, a failure to provide this will lead to employees working in unsafe environments, which can ultimately lead to accidents. The consequence among others is that the outcome of such accidents will have a negative effect on the health and safety performance of such organisations. Research in construction safety have proved characteristics of the work environment to be among the causes of construction accidents (Mattila et al., 1994; Arboleda & Abraham, 2004). When the work environment is unsafe, hazards loom around, some visible, others hidden, making accidents inevitable. It is therefore the duty of management, to provide management systems that can make work environment safe for workers as a way of preventing accidents emanating because of these hazards. The present study found that the work environment of many indigenous construction companies in Nigeria are not safe to work in, which points to management failure to provide a safe work environment for workers.

Slips, trips, and falls accidents are regarded as the most common causes of injury to workers. Alarmingly, they are classed as the initiators of accidents associated to other causes, like falls from height, scaffold accidents and some form of machinery accidents (HSE, 2013). In Nigerian construction, slips, trips and fall accidents have also been reported to be very common (Orji et al., 2016; Udo et al., 2016; Williams et al., 2018). They are caused majorly by factors

related to unsafe work environment. Examples wet or greasy floors, trailing wires and cables around the job site, uneven surfaces, poor lighting, uneven levels, unsuitable floor coverings, untidy tools, and poor housekeeping. Also, accidents like pierced by nails and sharp objects, and others are associated with unsafe work environment. Findings from this study suggest that indeed unsafe work environments are a root cause of construction accidents in the Nigerian construction industry. Most indigenous owned construction companies in the country are only interested in job completion over safety and so give no priority to making their work environment safe for workers. In the companies interviewed, workers in small-scale companies 1 and 2, and medium scale company 3 case 6 all complained about their work environment being dirty and filled with hazards, which was further confirmed based on observation of these sites by the researcher. Sadly, they must work around these hazards daily to earn their pay. A statement from B2 a participant from small-scale company 2 justifies this.

“There are some sites that are rough, all the nails on the floor is never packed. All the woods on the floor are never packed. If a site is rough whereby no one cares about the cleanliness of the site, accidents must happen because workers basically work on top of the dirty”.

Interestingly, majority of the accidents that happened in these companies found in the accident examples theme were pierced by accidents, slips, trips, and falls accidents, and objects falling and hitting workers. All element of unsafe work environment that can be eliminated with proper housekeeping. A look at one of the accidents in one of these companies justifies how unsafe work environment can be an accident heaven.

“It was about 2 years ago in one of our sites where we were trying to cast a concrete drain. I was in the site office when I heard a cry and came out to see what was happening. One of our workers who had no safety boots on had stepped on a 6inch nail that was standing erect on the floor. The nail entered deep into his foot. There is process when you want to cast a concrete drain, after giving elevations, the carpenter will come and get the form work braised, but unfortunately there was negligence on the part of the carpenter. He left a lot of nails on the floor; he did not pick up all of it after his own part of the job, which was done the day before. So, the mason came around to start his casting work the next day, as he was walking from one point to the other while doing his job, he was not wearing any safety boot, he stepped on the nail”

One of the first requirement of a safe work environment is cleanliness, which happens because of having a good housekeeping culture. A dirty work environment is an accident laden environment. Therefore, it is important that before, while on, and after each task, housekeeping should be done to clean the work environment so that accidents like pieced by nails, slips, trips, and falls, etc can be eliminated. Two things could have been done to prevent this accident: housekeeping by the carpenter after he finished his work; housekeeping by the mason before he commenced his work especially seeing that the work environment is dirty. However, management in these companies do not border about the safety of their operating environment. Of the three indigenous small-scale companies interviewed, only small-scale company 3 could boast of management plans put in place to keep their work environment safe. With the medium scale indigenous companies, cases 4 and 5 were Chevron sub-contractors working in a Chevron run project. Chevron invest greatly in safety and that includes management plans channelled towards having a safe work environment. So, these two medium scale companies work in safe environments. However, medium scale case 6, which is a major road construction firm in the country cannot boast of same. Based on observation of the worksite during the interview visit, it was a nightmare to say the least.

With reference to the above paragraphs, it is therefore safe to conclude that, in the Nigerian construction industry, majority of the indigenous construction companies do not provide a safe working environment for their workers. Thus, there is prevalent of accidents occurring because of this. Therefore, failure by management to provide a safe work environment for workers is classified as a root cause of construction accident in the industry. This finding is in line with findings of previous studies (Abdulhamid & Evereth, 2000; Toole, 2002; Arboleda & Abraham, 2004; Haslam et al., 2005; Chouldhry & Fang, 2008). This study further found that indigenous management do not provide safe work environment for workers because they see safety as being expensive and they lack the necessary finance to fund health and safety.

### **5.1.5. Negative behaviour and attitude towards safety by workers**

When accidents happen, the role humans play in its occurrence is undeniable. Hence in many accidents, it has been established that unsafe human behaviour plays a huge part, statistically causing about 88% of accidents (Garavan & O'brian, 2001; HSE, 2002). The behaviour of humans, be it negative or positive speaks of complexity such that they cannot be predicted

fully. Positive behaviour towards safety inform better safety performance. However, negative behaviour and attitude towards safety lead workers exhibiting unsafe behaviours.

Several factors can have confounded effects that influence the way, in which workers behave negatively towards safety. Education play a key role in the enlightenment process of workers. A lack of education can therefore be a factor responsible for negative behaviours. In the Nigerian construction industry, majority of the labour workers who carry out the main work in the field for most indigenous construction firms have little or no formal education. Also, many of these workers coupled with the aforementioned have no professional training with respect to construction job including health and safety trainings. Many are new and learn the job traditionally in the field from working with those that have some experience in the job, many of whom also do not have formal education and disregard safety. As reports from previous studies and findings from this study suggest, many indigenous construction companies do not offer training for workers when they are employed, making it difficult for these workers to understand key components of human behaviour and how these can affect safety on site. The statement from one of the interviewees corroborates this: “Many workers don’t have safety training before coming to do this job, because of that, we sometimes make a lot of mistakes, which lead to accident. So, if we have training, those mistakes will not be made, and we will not have these accidents. Because a lot of accident are caused by our actions, what we do and what we fail do”. Due to the lack in the area of formal education including in the area of safety trainings, these workers lack proper insight into the methods and techniques involved in construction works, lack knowledge of health and safety practices, lack injury and accident prevention skills, and have low insight into how some of their behaviours can result in accidents. Hence, they behave negatively, and sometimes, they may not even recognise these negative behaviours in their actions. This can create a bad social relationship in work teams and may affect how they make use of safety systems in the workplace. However, training of employees helps to build a good social relationship especially with new and old employees. Aside classroom training, assigning new employees with an old employee for on the job safety training will help promote positive safety behaviour on site (Mullen, 2002).

Furthermore, some workers fail to follow safety procedures when working on site. For example, many workers would refuse or fail to wear the personal protective equipment (PPE) given to them during work. Many times, this comes from workers that may even have experience but may have been lucky not to have been victims of fatal accidents. Behaviour

influences behaviour and people tend to quickly copy negative attributes. The essence of PPE's as the name suggests is to protect workers from hazards associated with the jobs. However, because the old workers refuse to make use of the PPE's, new workers tend to copy them and see no reason to use same when they are provided. On some other occasions the workers are not trained on how to use such PPE's and how using them can help them stay safe. Therefore, when PPE's are handed over to them, they use them wrongly, sell them, or not use them at all with reason being that they are not comfortable when they use them. These negative behaviours and mindset result in injury and death to workers. One of the labour participants in small-scale company 2 told of how wearing his hardhat on site saved his head from being broken when a falling object hit him on his head while walking around the worksite. He remarked that if he had not put his hardhat on, his head would have been broken. The same worker also thus:

“The company did not provide me any safety boot, any coverall, any hard hat, or gloves, I normally use my own money to buy these things. The eye goggle that I use right now, I do not like dirty getting into my eyes, [...] As soon as I discovered that the eye goggle, I brought from Julius Berger has expired, I went and bought another one for myself. If I do not use all these PPE's, anything like accidents can happen to me while I am working”.

This is a worker with a positive attitude and behaviour towards safety and it reflects in his actions. This positive attitude and behaviour according to the worker was developed when he worked with a multinational construction firm where he was trained on safe work practice. Hence the relevance of education and training of workers. It will among others correct the negative attitude and behaviour of workers and channel such attitude and behaviour towards a positive outcome.

The use of drugs and alcohol before work are never allowed on site because their effect on the brain can be dangerous. They can impair the judgement of the worker and make workers loose concentration while embarking on their task, thereby putting the worker(s) involved and co-workers at risk of accidents. What is discovered in construction is that some workers are in the unhealthy habit of making use of drugs and alcohol during work (Toole 2002). This can lead to accidents, which will not only affect the concerned workers, but also the co-workers working on site with such worker. The project manager in medium scale company 1 (Case Study 4) told the story of a worker whose action caused an accident on site in the accident investigation theme. He states: “there was a case, somebody that was working on that faithful day, we brought modules to be stored. These modules have been stored for some months. So, the fester



(what they use to hold the pipes, so that we can do tying on the other end so that the pipe will position properly) was being cut by a worker. After cutting, remaining the last one, he did not watch very well, he did not position well, immediately he cut the last one, the filters snapped and almost cut off one of his fingers. The case was reported to me [.....] and after treatment, we had to drug test. This thing that happened, is it that this man was not conscious of his self or what happened? Is it that he was under the influence of something? We were trying to trace the root cause. When we tested him, he tested positive, not alcohol, he took marijuana, [...] he is already sacked, and he cannot come back to the project”. This represent another case of negative behaviour by workers and this was dealt with appropriately by the company by sending the worker out of the site and terminating his appointment. The factor bringing about this behaviour on site has been attributed to job stress, long work hours, home problems, occupational and co-worker norms, tension brought by risk and unsafe conditions, and the presence of such drugs and alcohol in the workplace (Melia & Becerril, 2009). In Nigeria, cases like this are numerous in construction sites, especially the sites controlled by some small and medium scale indigenous firms in the country.

The influence of social and organisational factors can also bring about negative behaviour and attitude towards safety on site because these factors influences such behaviours (Mullen, 2004). For example, unsafe condition in the workplace. When they exist in a worksite, workers will take it as a normal practice to perform their construction activities by accepting the risks involved with the work. An interviewee stated “There are some site that are rough, all the nails on the floor is never packed, and all the woods on the floor are never packed. If a site is rough whereby no one cares about the cleanliness of the site, accidents must happen because workers basically work on top of the dirty”. It is evident here that when workers are faced with the condition of working in an unsafe environment, they accept this as normal and this influences their behaviour. Hence the need for management commitment to safety because if they are committed and provide a safe work environment, workers will also buy into that commitment and stay committed thereby encouraging positive attitude towards safety. An interviewee stated thus: “Management need to be responsible. They need to be example for others [...], if you are not committed, the workers will not be committed [...]. You are there to ensure that all policies are being followed, and you yourself must follow them”. When another interviewee was asked the most important role management can play towards promoting safety on site, he replied “The most important role management can play is to take safety seriously. When they take it serious, workers will take it seriously too and work safe”. However, findings in this study

suggest that in many indigenous construction firms, management do not take safety seriously. An interviewee stated: “Our local contractors here don’t regard safety. It is only a few local companies that you can find practising safety and most times it is maybe because they have contracts with big multinational companies and these big companies see safety as very important”. Positive safety attitude by management will create a positive attitude on workers and discourage negative behaviours.

Another example is performance pressure. It is believed that when workers face pressure to perform, the likelihood is that they end up engaging in ‘short cut’ work practice. By doing this, the need to quickly perform pushes them to the point that they waive safe work practice, making their behaviour towards safety negative. An interviewee stated thus: “Some of our managers, when you want to follow procedures, they tell you that you are delaying the job. They want the work done fast. So, this is where short cuts will come in”. On the long run, these practices have been found to become normal for the workers because with it, work is completed more quickly and sometimes times more efficiently (Mullen, 2004). However, it influences workers towards having negative behaviour towards safety. Incentives is another example that can bring about negative behaviour. While the use of incentives to boost performance is good, it also has its bad sides. One of such is that like performance pressure the use of incentives to boost performance encourages unsafe work practice.

Over confidence by workers can also lead to negative behaviour and attitude towards safety. Some workers tend to believe that because they have been involved in the job for a long period of time, they know it all. This belief makes them ignore safety. However, experience would not stop one from being an accident victim. In fact, experience has been proved to lead to reduction of carefulness (Gheradi & Nicolini, 2002). Mind overload also leads to negative behaviours on site. Many times, workers come to work with different problems on their minds. In safety trainings and pep talks workers are always asked to drop their problems at home while at work so that full concentration can be paid to the task at hand. However, a lot of workers cannot do this. They are carrying out tasks with different stressors on their heads leading to mis-concentration. All of which lead them to behaving in negative ways and exhibiting negative attitude towards safety.

The interview findings from this study reveal that negative behaviours were prevalent within the companies interviewed, and some of the accidents that were experienced in these companies were because of this. This can be seen from the accident narratives given in the

accident examples themes in chapter 4, the reason for accident themes and the discussions in previous paragraphs. This finding is in line with findings from previous study, which found that negative behaviour and attitude towards safety is a root cause of construction accidents (Abdulhamid & Evereth, 2000; Arboleda & Abraham, 2004; Haslam et al., 2005; Choudhry & Fang, 2008).

## **5.2. How and to what extent can lean tools such as the 5S Methodology, Visual Management, and the A3/PDCA Problem Solving Framework be used to Mitigate Accident Root Causes?**

In the previous section of this chapter, the root causes of construction accidents in the Nigerian construction industry were identified and discussed. In all, five root causes of construction accidents were discussed. This section shall explain how and to what extent lean construction tools such as the 5S Methodology, Visual Management and the A3/PDCA Problem Solving Framework can be used to mitigate these identified root causes. To achieve this, the section will discuss these tools separately starting with the 5S Methodology, Visual Management and then end with the A3/PDCA Problem Solving Framework. Along the line of this discussion, references will be made to section 5.2 and its subsections. This is to draw the connection on how these tools can help mitigate each root cause.

### **5.2.1. The 5S Methodology**

The importance of good housekeeping in construction sites cannot be over emphasized. Among others, it helps to eliminate problems associated with safety, improve workers morale, and increase efficiency and effectiveness while creating a safe and hazard free work environment for workers as they carry out their daily construction task (Becker, 2001). Findings from this research established that housekeeping is never done in most indigenous construction companies aside in a few, most of which are sub-contractors to multinational firms and work using the safety guidelines of these firms. A look at the types of accidents that were experienced by participants in the example themes showed that struck by falling objects, pierced by nails and sharp objects, and slips, trips and falls were prevalent. A summary list of the types of accident experienced by participants from the interviews is attached in appendix (5). The summary list also shows that struck by falling objects, pierced by nails or sharp objects, slips, trips, and falls, and electrocutions accidents were prevalent in the Nigerian construction industry. The root causes of these accidents in the Nigerian construction industry have been highlighted in section 5.2. of this chapter. These are accidents and their root causes that can be avoided and mitigated. How this can be done is through a methodological application of a good housekeeping methodology that lay focus on both the social and technical areas of the work

environment. A truly tested and validated housekeeping tool that can help achieve this for any organisation is the 5S housekeeping methodology, which is a lean continuous improvement tool (Mastroianni & Abdelhamid, 2003; Salem et al., 2005; Leino et al., 2014). The implementation of the 5S in construction in Nigeria can help address the identified accident root causes in this study as shown in figure 6.

The 5S methodology is known in Japan as the basic principle of industrial housekeeping. It is a technique used in organisations to establish and maintain quality environment (Ho, 1999; Poornima, 2011). It uses five basic steps each starting with the letter “S” to systematically clean the work environment creating a place for everything and everything in its place to sustain a productive work environment built on the culture of continuous improvements. The 5S represents five Japanese words in the order: seiri, seiton, seiso, seiketsu and shitsukes, which make up the steps used in establishing, achieving, and maintaining a quality environment. In English, these five words mean sort, set in order, shine, standardize, and sustain.

Before any 5S implementation is embarked upon, first thing that is provided is training of employees on the use of the 5S tool. (Kumar & Kumar, 2012). This training creates a lot of positives towards the 5S implementation process and towards providing basic knowledge on how to embark on the 5S exercise to achieve a perfect housekeeping regime leading to a quality environment. Findings from this study has established that many indigenous construction companies do not provide safety trainings or adequate safety trainings for their employees. This has been established to be one of the root causes of accidents in the Nigerian construction industry. Therefore, the implementation of the 5S in Nigerian construction sites can serve as a good conduit for providing extra trainings for the employees. As employees are trained in 5S methodology, such training creates an opportunity for them to be trained in health and safety. Hence, the 5S training will help to address root cause number (1) by providing information, knowledge, and training for employees on health and safety. Such trainings will positively impact the ability of management and employees to be able to understand how to make the work environment clean and safe and what constitute hazards and unsafe conditions. Therefore, this will also contribute to mitigating root cause numbers 2 because it teaches workers and employees what hazards are in the work sites, so that they are able to identify them when they see them. It will also contribute to making workers understand that when they see hazards or unsafe conditions, they should not just ignore them as doing so will lead to accidents. Therefore, it will contribute to making workers stop work and eliminate unsafe conditions and

hazards when they see them while working, thereby contributing to mitigating root cause number 3. The 5S training will also contribute to mitigating root cause number 4 because management also take part in the training. It will educate them on the need for providing a safe work environment, which is what the 5S is about.

A participant in small-scale company 1 told of how he works safe because of the training he got working with a multinational company in the past. He states: “I clean anywhere I want to work because of the training I have from my previous company in Abuja. We always do housekeeping down there” This statement portrays how the training he got from his previous company impacted the good behavioural attribute in him, which he now exhibits in this new company he is working with even though the company does not give health and safety a priority. He cleans his work environment before he starts work, he takes the extra caution of buying himself PPE’s to stay safe. His comment about other workers however portrays how a lack of training can influence the behaviour of workers. He states: “But here, some workers just start work without even cleaning the work environment”. These sets of workers are part of those that exhibit negative behaviours and attitude towards safety. The 5S training will therefore also help to address root cause number (5), which has to do with negative behaviour and attitude towards safety by workers. It will also help build interpersonal social relationship between workforce, and a sociotechnical relationship with how they use tools and techniques in the work site. Hence in the 5S findings section in chapter 4, participants stated the need for trainings on the use of the 5S. They stated that without training on its use, its implementation will not be successful. This finding supports findings from previous studies (Osada, 1991: Kumar & Kumar, 2012) that not providing adequate training to employees can result in failure for organisations using the 5S. Further, findings from the study suggest that a lack of safety training can be the foundation of workers negative attitude and behaviour.

The first step of the 5S is SORT. In a construction site, there are always a lot of materials and tools, junks scattered all over making the sites unsafe to work in. While some of the tools and materials are needed for immediate tasks, others might be needed for later tasks and others are just rubbish that are not needed for anything. However, what is discovered is that on site, all these tools, materials and junks are mixed and scattered all over. This makes it difficult to find tools in the work area, have easy access to materials that are needed for immediate use in the work area and makes the work area congested with hazards both hidden and visible. The SORT step of the 5S helps to identify whether a material on site is needed or not (Yang et al., 2004).

In this step, the materials needed are separated from the ones that are not needed. The materials not needed are taken off to a 5S holding area and red tagged to show that they should be taken off the work area (Kumar & Kumar, 2012). With many indigenous construction sites in Nigerian being congested with no form of sorting done as the findings from this study has revealed, the application of the sort step in a construction site in Nigeria will help workers to understand the importance of arranging different tools, materials and equipment in the worksite. When equipment, tools and materials are sorted in their worksites, workers know where to look to get them as opposed to searching for them. This helps to eliminate time wasted in searching and it enhances efficiency and quality.

In the words of the project manager for small scale company 2, “it would make my job to be done in a more simplified manner. It brings about accountability in the sense that with the proper arrangement of tools, you know when a particular tool is missing and when it’s not missing”. The sort step will also help Nigerian construction workers to get rid of clusters from the work environment. Clusters hide problems in the worksite and make abnormalities difficult to detect. However, when materials, tools, equipment and junks are sorted in the work area, abnormalities become visible and workers can see what is going on in and around the workplace clearly as they move about carrying out their daily task. As stated by a participant in small-scale company 2, “when the work environment is clean, accidents like slips, trips and falls, nails and sharp objects piercing people’s legs, electric wire on the floor electrocuting workers that accidentally step on them, tools falling on someone, these and other accidents are all prevented” Therefore, application of the SORT stage of the 5S in the Nigerian construction industry can contribute in mitigating root cause number 2, which is the inability to identify or recognise hazard/unsafe conditions in the worksite before the start of task.

It will also contribute to mitigating root cause number 3, which is identifying a hazard/unsafe condition and continuing with work without first eliminating the hazard/unsafe condition. The application of this step will also contribute to mitigating root cause number 4, which is management failure to provide a safe environment. Because when management apply this step in the Nigerian construction industry, it will help in the process of making the work environment safe for workers. The sort stage will also contribute to addressing root cause number 5, which deals with workers negative behaviour and attitude towards work. This is because when workers begin to see the benefit derived from sorting things in the work environment, it changes their negative behavioural outlook towards work to positives. For

example, the zeal to always want to sort tools and materials in the work site can become an inbuilt norm.

The second step of the 5S is SET IN ORDER. A slogan for this stage of the 5S in lean is “A place for everything, and everything in its place” (Mastrojanni & Abdelhamid, 2003). This occurs after all the junks in the worksite has been removed from the sorting stage. What is left, which are classed as things that are needed for work in the worksite are then effectively organized, stored in accessible area of the work zone, and boldly labelled so that those working in the work area can easily find what they want with ease. According to findings from this study, some of the hazards that lead to accidents in construction sites result from lack of clear access way for movement because materials, tools and equipment blocks access ways in the worksite preventing easy movement. This sometimes leads to slip trips and fall accidents, which has been classed as one of the most common types of accident in the construction industry (Leino et al., 2014). One of the goals of the set-in-order stage is to create workplace where navigation can be easy. Application of the set-order stage in construction sites in Nigeria can help create this kind of work environment where there is space for navigation and movement, and reduce slips, trips, and falls and other accident resulting from lack of space for movement.

Another hazard deals with work tools and materials being placed and left in different places in the work area after use. When they are then needed for re-use, finding them becomes a problem. This then results in time wasted searching for these tools and materials leading to less productivity. It also leads to workers making use of wrong tools and materials because the right tools or materials cannot be found for the immediate job. Sometimes, this result to accident from use of wrong tools. Therefore, the application of the set-in-order stage can help make tools and materials readily available and close to workers thereby reducing time wasted looking for tools, and accidents resulting from use of wrong tools. The application of the set-in-order stage of the 5S in Nigerian construction sites will contribute to mitigating root cause number 2, which is the inability to identify hazard/unsafe conditions in the worksite before the start of task. This is because work tools, equipment and materials are also parts of what constitutes hazards and unsafe conditions in the worksite when they are left scattered and unorganised (Howell et al., 2002). By setting them in order, their ability to become catalyst for accident are reduced if not mitigated.



Also, setting the tools and materials in order means workers have seen and now understand the potential danger they can cause if they are left scattered and unorganized. Therefore, by setting these tools and materials in order, root cause number 3, which is identifying hazards/unsafe conditions and continuing with work without first eliminating the hazard/unsafe conditions is mitigated with respect to tools, materials, and equipment's. This stage also contributes to making the work environment safe for workers to work in. Therefore, the set-in-order stage is another way management can provide a safe working environment for its workers. This stage will help mitigate root cause number 4. When workers come together to set tools, materials, and equipment's to create a clean and safe worksite, it portrays a positive attitude towards safety. Therefore, to some extent, the set-in-order stage can also help workers to build a good attitude towards work thereby contributing to mitigating root cause number 5 dealing with negative behaviour and attitude towards safety by workers.

The third step of the 5S is SHINE. This stage means to thoroughly clean the work environment, including equipment and tools on a regular basis such that everything is returned to a nearly new state. In the accident example theme in chapter 4, there were cases where workers were pierced by nails and sharp objects while working on site (see sections 4.2.1 and 4.3.1). There were also cases of accident because of using uninspected machineries for job execution (see sections 4.2.1, 4.3.1, 4.6.1). In some of the companies interviewed, workers complained about the unsafe condition of their sites. Speaking about an accident, one participant stated thus: "Last week, one of our workers had a bad nail injury. He stepped on a nail while he was walking around the site. You know how construction sites are, some a very dirty with so many hazards everywhere [...]. He is still at home as we speak". Another participant had stated: "There are some sites that are rough, all the nails on the floor is never packed. All the woods on the floor are never packed. If a site is rough whereby no one cares about the cleanliness of the site, accidents must happen because workers basically work on top of the dirty". These narratives show how unsafe some sites can be and how accidents can happen because of this. The application of the shine stage in construction sites in Nigeria can help to keep construction sites clean and shining thereby eliminating the chances of accidents like slips, trips and falls, faulty machine accidents, pierced by nails accidents, fall from scaffold, electrocution, hit by falling objects, pollution and many more.

The shine stage of the 5S will not only eliminate the above identified accidents, it will also eliminate their root causes. For example, the second root cause identified referred to the

inability of workers to identify or recognise hazards/unsafe conditions in the worksite before the start of task. By regularly cleaning the worksites, tools, and equipment, these hazards and unsafe conditions in the sites are detected and eliminated, faulty tools and equipment's are identified and taken off for repairs, danger spots in the work areas are detected and visual signs are strategically placed to warn of the dangers. Therefore, the worksite can be free from hazards and unsafe conditions. Coupled with the 5S training workers get before the start of the 5S implementation, when hazards pop up as they work, workers would be able to identify and eliminate them. This ultimately also contribute to mitigating root cause number 3. Shine also contribute to management's ways of creating a safe working environment for workers, which is root cause number 4.

The fourth step of the 5S, which is STANDARDIZE is management control step to make the first three steps a standard within organisations. To standardize means to maintain the neatness continually, and repeatedly, and cleaning standards of the organisation, established in the first three stages (Poornima, 2011). In this accident narrative by the project supervisor for small-scale company 1: "It was about 2 years ago in one of our sites where we were trying to cast a concrete drain. I was in the site office when I heard a cry and came out to see what was happening. One of our workers who had no safety boots on had stepped on a 6inch nail that was standing erect on the floor. The nail entered deep into his foot. There is process when you want to cast a concrete drain, after giving elevations, the carpenter will come and get the form work braised, but unfortunately there was negligence on the part of the carpenter. He left a lot of nails on the floor; he did not pick up all of it after his own part of the job, which was done the day before. So, the mason came around to start his casting work the next day, as he was walking from one point to the other while doing his job, he was not wearing any safety boot, he stepped on the nail".

The carpenter did not clean up after his task the previous day because the company had no housekeeping culture. The mason also did not clean up same work location before the start of his task the next day due to the same reason. Hence the resultant accident. The findings from this study suggest that this situation is common with indigenous construction firms in the country and not limited to just small-scale company 1. Even if the first three steps of the 5S is applied in this worksite and others, without standardization of the steps, workers will not conform to maintaining the neatness and cleaning standards established. Application of the standardization step by management of construction companies in Nigeria will ensure that

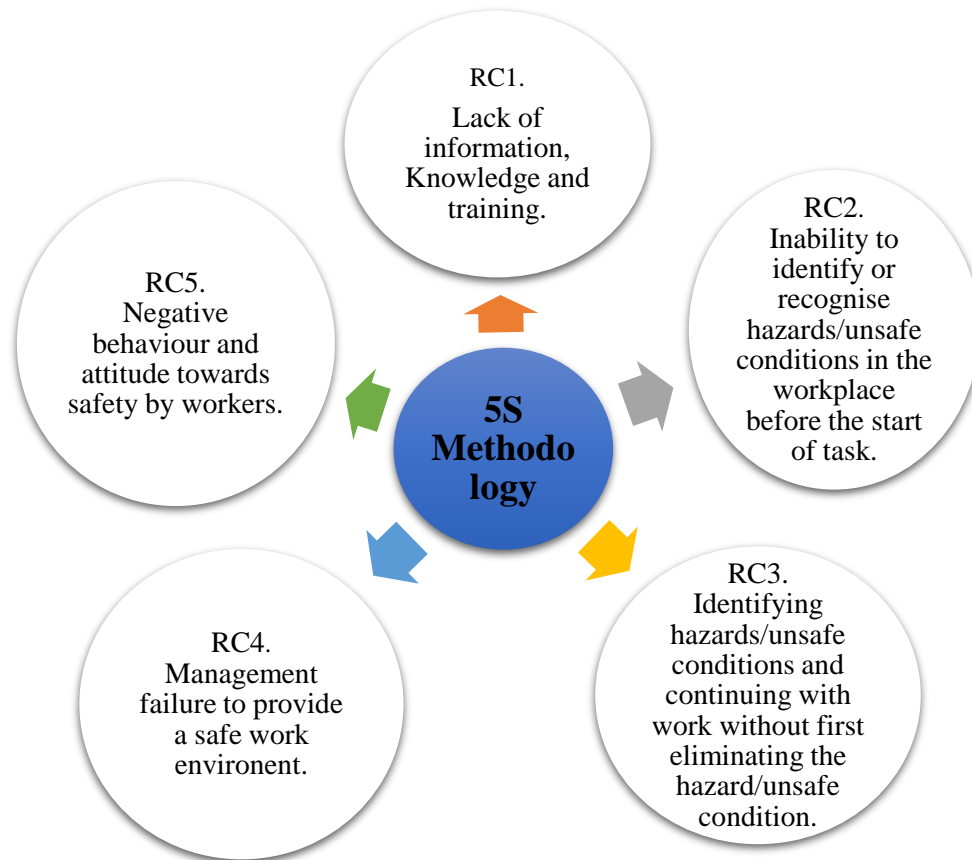
workers maintain the status quo achieved in the first three stages of the 5S and therefore highly contribute to continually mitigating the root causes the first three phases mitigates. Management can make use of daily checklists in form of key performance indicators (KPI's), visibly displayed in the work locations. The checklist must be signed daily by workers after completion of tasks to show compliance to standards. To ensure the success of this, site managers, safety officers and supervisors can go around the site for inspections to maintain standards. Standardization will help to solidify the relationship between the management, workers, and the safety system they make use of to achieve an accident free worksite.

The last stage of the 5S is SUSTAIN. This is also a management control step. This stage of the process is about keeping rules so that the standard procedures of order and cleanliness already in place through application of the first four stages of the 5S can be maintained (Poornima, 2011). Some of the findings of this study suggest that sustaining the 5S may be a problem with construction organisations in the country. Two reasons were given for this. First is that management may be the first to default because of the poor safety culture of many indigenous construction firms in the country, which sometimes involve supervisors hurrying workers to finish work on time over safety of the workers. Second is that some workers may not be interested in cleaning before work. If the first issue can be solved, then the second issue will not be a problem because of management control. This finding is in line with findings from previous studies that conclude that sustaining the 5S is challenging (Mastrojanni & Abdelhamid, 2003). To solve the first issue, management must be committed to the 5S program and must show this commitment by constant retraining of employees on the 5S, by adhering to the rules of the 5S themselves, by making use of reporting metrics and having regular 5S audit, by introduction of reward programs to reward employees on their use of the 5S technique, by having a 5S slogan contest (Kumar & Kumar, 2012; Edwards, 2015). The overall goal of sustain is to promote good behaviour and discipline and to promote continuous use of the 5S system. This will in turn contribute to mitigating the root causes identified in this study. Also, because the focus of sustain requires self-discipline, application of this phase can contribute towards mitigating root cause number 5, which is negative behaviour and attitude towards safety by workers (Kumar & Kumar, 2012). The sustain step can be used to correct the behaviour of workers. This will contribute towards making workers make use of the technical system in place thereby encouraging a sociotechnical relationship, which is the umbrella cover for this study.

The implementation of the 5S in construction process from literature reviewed in this study have shown that 5S can be used in mitigating the causes of accidents in construction sites (Howell et al.2002; Bashir et al., 2012; Leino et al., 2014, Enshassi & Zaiter, 2014; Marhani et al., 2018). In the findings section of this thesis, some participants stated that they have worked with multination companies in the past that had made use of the 5S housekeeping strategy. They reported that the use of the 5S system in those companies helped to reduce the occurrence of accidents in their sites and made their jobs quicker. Studies like Salem et al. (2005), Leino et al. (2014) and Tezel & Aziz (2016) validates this. However, in the companies investigated, this study found that some indigenous construction companies in Nigeria do not carry out any form of housekeeping at all, aside a few like small-case company 3. Even this company does not have a good housekeeping practice as explained by the company's safety officer. However, the safety officer did state that they are trying to introduce a proper housekeeping method as a means of reducing accidents in the company. Majority of the indigenous companies that engage in proper housekeeping methods are those companies like medium scale companies 1 and 2 that work as sub-contractors to multinational companies and works with the housekeeping practice of these companies. Participants from these two medium scale companies however did state that compared to the housekeeping technique they use on their sites, the 5S methodology is a more detailed and comprehensive housekeeping technique.

As earlier stated in the starting paragraph of this section, the importance of housekeeping cannot be overemphasized. In fact, the project manager for one of the companies stated thus “I believe that housekeeping is key in a construction site. As soon as that has been properly taken care of, in my own opinion it reduces the risk of an accident occurring to a very large extent, like 90%”. As part of the findings from this study, five root causes of accidents in the Nigerian construction industry was identified. While the 5S methodology on its own cannot totally mitigate these identified root causes, this study has found that the full implementation of the 5S methodology in Nigerian construction sites can significantly contribute to mitigating all aspects of the five identified root causes as represented in Figure (7) below based on evidence from the paragraphs that make up this section. RC in each circle of the diagram represents “Root Cause”. Therefore, the result of implementing the 5S will make any construction organisation making use of it safer to work in. Also, as these organisations roll out the 5S, this gives the opportunity for management to engage with their workforce to provide training on the both the technical and social aspect of the work environment. This finding is therefore in line with findings from previous research that the application of 5S methodology in

construction sites can help in preventing accidents on sites (Salem et al., 2005; Bashir et al., 2012; Leino et al., 2014; Enshassi & Zaiter, 2014; Tezel & Aziz, 2016; Marhani et al., 2018).



*Figure 7 5S Mitigation of Accident Root Causes in the Nigerian Construction Industry*

### **5.2.2. Visual Management**

Visual management refers to the managerial strategy of consciously integrating visual tools in workspaces with the aim of increasing transparency in construction sites (Tezel et al., 2015). One of the major challenges in construction worksites deals with safety of workers. To be able to overcome this challenge, it is important for organisations to create a visual workplace by using visual tools such as signages to alert people about potentially hazardous situations, including preventing unsafe conditions in the workspace. The belief is that when these information's are communicated visually in the workplace, workers and visitors to the site would not require any interpretation to understand them. They Findings from this study has established that indigenous construction companies in the Nigerian construction industry are

aware of and make use of visual tools in their worksites. Many of these companies use visual tools mainly for accident prevention. However, not all these companies utilize the use of these tools to its full capacity. The reason for this is may be that perhaps these companies do not have full awareness about what visual management is (Tezel et al., 2011). Based on observation of some sites during the data collection stage of this research, the use of visual signs was especially very minimal within the construction sites of these indigenous companies except for medium scale companies 1 and 2. So many places in the worksite of these companies that would have benefitted from the use of visual signs were left without signages raising the risk of potential accidents to workers. Although, there was a consensus belief that the use of visual signs no matter how minimal have helped with accident prevention both in the past and present within the companies. If well utilized, the application of visual management techniques in construction sites in the country can yield even better result in terms of accident prevention and thus greatly improve safety performance as seen by results from its implementation in previous studies (Jang & Kim, 2007; Awada et al., 2016; Abdelkhalek, et al., 2019).

In section 5.1 of this chapter, the root causes of construction accidents in the Nigerian construction industry were identified. Visual management can contribute in a great way in helping to mitigate some or all the root causes identified in this study as shown in figure 7 if management implement it as part of their safety management system. For example, the first root cause identified in this study has to do with lack of information, and training. When a company invest in visual management, part of that investment will be towards training of their employees. The trainings create another opportunity for the social bundle of the companies, which are the employees to be trained on health and safety, which can help them to understand the various ways accidents can occur in the work site and what can cause them, including how the use of the visual signs (technical bundle) can help eliminate some of the accidents. As a system, visual management provides real-time information on workplace status (Shmula, 2012). Such information come in form of instructions to workers on the right way to do things even when no one is watching (Kovera, 2014). For example, when a signage is placed in the worksite displaying to workers to “wear their PPE’s” with pictures of PPE’s clearly displayed on the signage, this reminds the workers on the need to stay safe by wearing their PPE’s at all time without being told by the safety officer. In this way, use of visual signs influences the behaviour of workers and their commitment to the use of PPE’s (Brady, 2014 Abdelkhalek et al., 2019). Therefore, as an information designation tool, visual management help to continuously provide knowledge and instructions to workers in the worksite. By

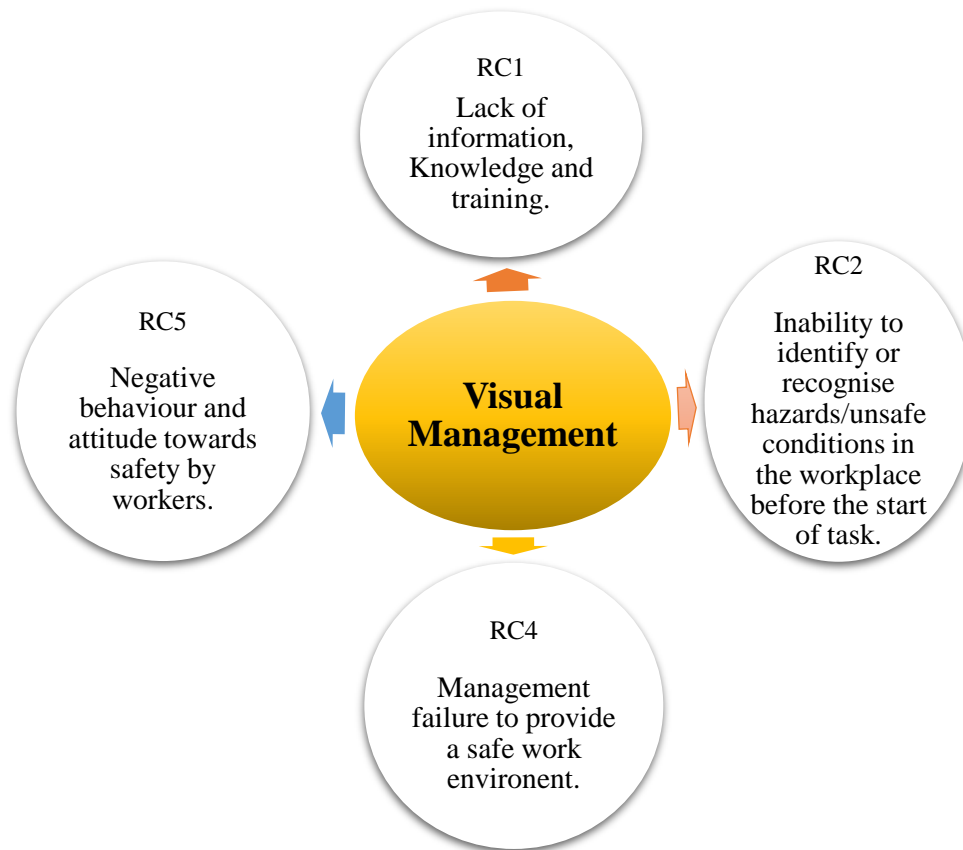
communicating important safety instructions, visual tools help companies to maintain a safe site environment (Awada, 2016). The use of visual tools on site will therefore contribute to mitigating root cause number 1, which is lack of information, knowledge and training, root cause number 4 dealing with management failure to provide a safe environment and root cause number 5 dealing with negative behaviour and attitude towards safety by workers.

Furthermore, workers inability to identify hazards or unsafe conditions in the worksite before the start of tasks was identified as a root cause in this study. One of the main aims of visual management is to increase transparency on site (Tezel et al., 2015) Part of the ways of achieving transparency is by cleaning and organising the worksite using the 5S (Tezel, 2014; Tezel et al., 2015). Aside eliminating hazards, the 5S also help to make abnormalities visible in the worksite as already established in the previous section. In a visual worksite, abnormalities hazards, and unsafe conditions are made transparent and visible by use of visual signages to indicate where there are possible or potential dangers so that workers do not go towards the danger. Therefore, by using visual tools on sites, workers can easily identify hazards or unsafe conditions and thus accident is prevented. In the accident example theme, the project manager for medium scale company 2 case 5 spoke about a fatal accident that resulted in death. “This one happened in our site in the Escravos Gas to Liquid Project (EGTL). They were servicing a crane and the boom was boom out, they were working on the hydraulic system that was moving the boom in and out. So, something happened that they had to go on break and the boom was out. So, all they had to do, was put it to the resting position, keep it safely before they go out for break. However, they left it there like that and there was no barricade or barrier around the place to tell onlookers, passers-by and most of the people who are working in that area that okay do not go there. That was how it was left. So, somebody went there, and sat under the shadow of the boom, because it was in the middle of the afternoon, taking a nap there. So, the boom now dropped on the person. He died instantly and that was how we lost that personnel”. This indicate the importance of using visual signs on site to warn about danger. If there was a signage or barricade strategically placed signalling the danger situation of the crane, the victim would have avoided sitting under the crane. The use of visual signs on site can greatly reduce the rate of accidents. When Kanban system was implemented in a civil construction site, there was a decrease of about 33% in accidents rates, and in two other companies the accident percentage after its implementation was zero (Jang & Kim, 2007). Therefore, when visual signages are applied on site in the Nigerian construction industry, visual signs will help to expose where hazards and unsafe conditions are in the worksite to the workers. In this way, the use of visual

management techniques on site can contribute to mitigating the inability of workers to identify hazards or unsafe conditions in the worksite before the start of tasks, thus eliminate the accidents that can result if such hazards and unsafe conditions are not exposed.

In conclusion, visual management provides another way for management to connect because as they develop their visual management strategies, they will have to connect with employees working on site. This then provides an opportunity for management and the workforce to discuss issues pertaining to where accidents and near misses has occurred in the site, places in the site that they think are potential risk zones and so on. The result of such meetings will inform decisions on locations in the worksite that need visual signs e.g. where warning signs are needed, where caution signs are needed, where safety posters are needed. It also provides opportunities to discuss overall safety performance including tracking performance. When Nigerian construction companies applies all these, it will help management to build a good social and technical relationship between the workforce and the visual management system in the organisation. It will also contribute to mitigating some of the root causes identified in this study as depicted in Figure (8). Ultimately leading to better safety performance, healthy interpersonal relationships, visualized work location free from accidents and near misses. The findings from this study agrees with previous studies that the use of visual management in construction sites can help prevent accidents thereby improving safety (Heineck et al., 2002; Jang & Kim, 2007; Tezel, 2013; Abdelkhalek et al., 2019).





*Figure 8 Visual Management mitigation of Accident Root Causes in the Nigerian Construction Industry*

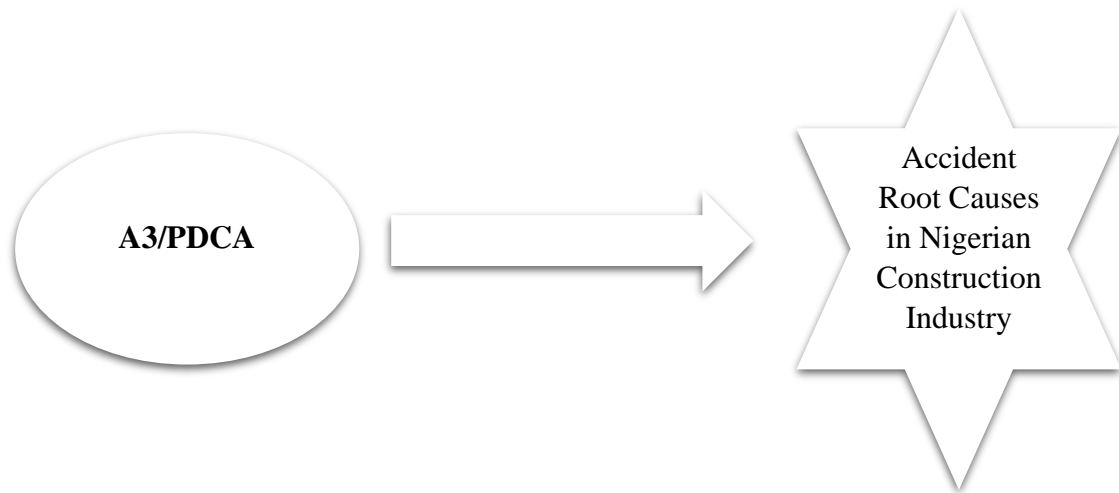
### **5.2.3. A3/PDCA Problem Solving Framework**

Organisational problems abound everyday irrespective of size and financial powers of such organisations. Problems could arise from any area of the organisations business structures, which if left unsolved can lead to so many negative outcomes that could negatively affect business. In construction one of such problems deals with health and safety. Specifically, accidents and its occurrence. Worldwide, this is a major problem for construction organisations. The A3/PDCA problem solving framework is a framework that organisations can employ to find out the root cause of such problems and to solve the problems when they arise (Shook, 2008). A3 is a visual manifestation of a problem-solving thought process involving continual dialogue between the owner of an issue and others in an organisation. As the name suggest, the A3 is an international size piece of paper with a solid structure for the implementation of the Plan, Do Check, Act (PDCA). The PDCA is a system used for the continuous improvement and management of organisations. The purpose of the A3 therefore is to document on one page, the results from the PDCA (Shoot, 2008; Schwagerman & Ulmer,

2013). The use of this framework in Nigeria by indigenous construction companies can help to methodologically and effectively solve problems related to safety on site. Especially when the findings from this study reveal that some indigenous construction companies in the country hardly have a framework, which they make use of when they have problems. When these companies experience accidents, they can follow the structure of the A3/PDCA to get to the root causes of the accidents and even provide counter measures to eliminate these root causes. Importantly this framework creates an opportunity for management to engage with workers in the field because PDCA cannot be done seating in the office disconnected from what is going on in the sites, and from the workers on the site. So, for example to find out the root cause of a recurrent type of accident on site, workers on site need to be engaged. When management start to work through the PDCA cycle, the Plan phase creates an avenue for all parties to the accident to be involved in stating and providing a background to the accident. This makes it possible for all parties to have a common understanding about the accident, including the identified root cause(s) using the 5Y root causes analysis tool, which is a tool some of the indigenous construction companies already make use of. In the Do phase, management can now provide counter measures to address the root causes identified. One of the root causes identified could be that these accidents happen because workers lack training. The counter measure for this will then be to provide training. This will then be an opportunity for management to take action to provide more training for workers. This will for example help to contribute to mitigating the lack of training root cause identified in this study. Another root cause can be that the accidents happen because the work environment are always dirty and unsafe to work in. The counter measure for this can be that management have to introduce a safety management system that can make the work environment safe to work in. This will then be an opportunity for management to say let us do 5S, let us do visual management. Again, workers will have to be trained on all of these. After applying all these counter measures, management can now use the Check phase to study the effect the trainings, and the implementations of the 5S and Visual management have had on the root causes. Did the training and implementations of the 5S and VM help mitigate these root causes, did they not? The Act phase can then be used to analyse the results. Depending on the outcome, if the results comes out positive, then management team goes through the PDCA cycle again. This time to find out how to standardize the success. However, if the results come out negative, the PDCA will have to be repeated (Schwagerman & Ulmer, 2013).

The application of this root cause diagnostic tool by management of construction companies in Nigeria will help in a lot of ways in helping solve accident problems on site. First, doing the A3/PDCA cycle creates opportunities for positive relationship building between workers, work teams and work systems. By training workers and allowing workers to be part of the problem-solving team, a sense of value and belonging is built fostering on promoting deliberative and thoughtful decision making (Sobek & Smalley, 2008; William, 2010). This can positively affect behaviour and create an environment where all workers want to work towards the success of the organisation. Second, when the A3/PDCA provide counter measures for problems identified, it creates solutions to those counter measures. By providing for example safety systems to improve health and safety performance, and training workers on how to make use of and engage with these systems, management is building a sociotechnical system environment where both the social angle and the technical angle of the work environment is given equal consideration considering the fact that technical systems have a strong influence on social systems (Trist & Bamfort, 1951). So, when this relationship is built, better performance is achieved. Third, the result from both end of the cycle whether positive or negative takes you to a continuous repeat step of the cycle. Either one repeats the cycle because the first PDCA cycle did not create the needed solution and so must be redone, or because it created the needed solution and there is need to improve further on the already improved solution. By this the application of the A3/PDCA can help Nigerian indigenous construction firms to continuously improve. This is way better than what is obtained right now where there are no problem-solving systems in use in most of these companies leading to constantly re-occurring problems with no solutions.

In conclusion, going through the A3/PDCA cycle will help construction companies in Nigeria to address the root causes of construction accidents identified by this study as shown in Figure (9). Also, it can be applied by companies as a diagnostic tool to dig out and address the root causes of whatever problem they face, not only safety. By helping diagnose and address these root causes, problems are solved. This in line with previous studies that consider the A3/PDCA a problem-solving tool (Shook, 2008:2009; Schwagerman & Ulmer, 2013).



*Figure 9 A3/PDCA Diagnostic*

### **5.3. A Conceptual Lean Framework to allow Organisations to Diagnose and Improve Health and Safety Performance**

Building from the discussions on the root causes of accidents in the Nigerian construction industry, it was established in the section preceding this that lean construction tools such as the 5S, visual management and the A3/PDCA problem solving framework can mitigate the identified root causes. To satisfy the third objective of this study, a lean conceptual framework that construction organisations can make use of to diagnose and improve health and safety performance in the Nigerian construction industry will be developed.

#### **5.3.1. Lean Safety Framework (LSF)**

The lean safety framework (LSF) as shown in Figure (10) consists of several element that make up the body of this research. These elements will be discussed using major headings of the components of the framework.

##### **5.3.1.1. The Sociotechnical Work Environment**

The big square box represents the construction site itself, which is classed here as the sociotechnical work environment. This is where all the construction jobs take place. It is referred to as the sociotechnical work environment because all elements that make up a sociotechnical system, works and are used in this environment. E.g. the construction workers and the safety system like the 5S, Visual Management and the A3/PDCA. The construction workers, including the organisation are the social part of the work environment, while the safety systems like the 5S, Visual Management and A3/PDCA are the technical systems provided by management, to be used by workers to keep them safe by preventing accidents while they carry out their various tasks on site. Previous research had discussed the insufficiencies of traditional efforts in dealing with workplace safety (Carayon et a., 2015). The traditional method according to authors only focus on the individual and does not take into perspective, the broader sociotechnical aspect of the environment surrounding the workers. To correct this, authors suggested placing focus on the broader context of work, namely the social, organisational, and technical environment.

The LSF embraces all of this and believe that to prevent accidents all these elements must work together hence the framework inculcate the social and organisational elements (management and labour workers) and technical element (lean tools) into the work environment as seen in the framework (Mumford, 2006). One of the root causes identified in construction accident deals with management not being able provide a safe work environment for employees (Arboleda & Abraham, 2004; Chouldhry & Fang, 2008). By inculcating the 5S, VM and the A3/PDCA lean tools into the work environment as accident prevention measures, the work environment is made safe for workers to work in and elements in the work environment that can cause accidents or result to workers being accident victims can be eliminated as noted from previous studies focusing on implementation of these lean tools in projects (Enshassi & Zaiter, 2014; Awada et al., 2016; Marhani et al., 2018; Abdelkhalek, et al., 2019).

The outcome of having a sociotechnical work environment would lead construction organisations in Nigeria to know better ways of understanding how humans, social, and organisational factors within the work environment affect the ways work is carried out and how the technical systems like the 5S, VM and A3/PDCA are made use of to balance the work systems (Baxter & Sommerville, 2011). This would bring about a better understanding of Lean techniques at all organisational levels, help organisations and management to keep the work environment clean and safe for its workers and increase safety performance. It would further help organisations save cost channelled towards compensations and treatment of victims, repairs of and purchase of new tools and equipment from effects of accidents, etc (Oxenburgh & Marlow, 2005; Jallon et al. 2011; Yin et al., 2018, Zainon et al., 2018).

### **5.3.1.2. The Management (Lean Safety Framework)**

The LSF is a management safety system. Therefore, in the Lean Safety Framework, the first element on the left is the management (Company Management). They control how the site (sociotechnical work environment) operates, including all safety aspects in the work environment. Regarding organisational safety, management have a huge duty to provide and control all elements within the work environment to make it as safe as possible to work in for workers. Hence, the responsibility for safety lay on management (Heinrich, 1931). Thus, in the Lean Safety Framework, management are the ones that have control of the two most important steps, which are to maintain standards of working as the framework directs and sustaining the

work ethics for continuous improvements (Mastrojanni & Abdelhamid, 2003; Poornima, 2011).

To maintain standards and sustain work ethics, it is very important that workers who will make use of the framework receive trainings on all elements that make it up, including how the framework can be safely applied and sustained in the sociotechnical work environment to prevent accidents. The importance of training cannot be overemphasized. Amongst others, it teaches workers the difference between safe and unsafe behaviour and work practice; it enables workers to properly recognise and avoid potential hazards associated with the job while working as well as understand the steps to take to eliminate such hazards; it helps in encouraging employees to become actively involved in the application exercises and provide workers with basic knowledge needed to embark on the application of the framework (Arboleda & Abraham, 2004; Kumar & Kumar, 2012). Training workers on the use of the framework would make the workers understand how each element of the 5S, VM, and A3/PDCA interact with one another to improve safety performance in the sociotechnical work environment and would make them know how to be responsible (Zang et al., 2004). Management are the ones saddled with the duty to provide these lean training and retraining for workers on the use of the framework, including implementation guidelines.

Furthermore, management are the ones to provide means of standardizing the system through implementing the use of key performance indicators (KPI's) to monitor and measure performance and improvements. E.g. using checklists, setting targets, and tracking the progress against the set targets. By using KPI's, management would know if the framework is being followed, and if not being followed, they can thus find out why and look for better ways by which standards can be followed, including taking of disciplinary actions and creating disciplinary process that focus on ways of changing how people behave through a training process that focus on being responsible (Yang et al., 2004). They can identify opportunities and therefore plan for more changes while continuously assessing results. They are the ones to introduce reward programs to encourage compliance and better performance standards. When safety problems occur, they are the ones to make use of the A3/PDCA tool to find out the root causes of such problems. Management are the one saddled with carrying out 5S audit through use of 5S audit checklists to evaluate the implementation of the framework, making sure all steps are followed in the workplace. These are important functions that determines the success of the framework towards continuous improvement.

Importantly, the sociotechnical relationship cannot survive without management, therefore, management must play these roles to harmonize the social and technical elements of the work environment to achieve optimum results and rewards (Mumford, 2006). The focus of lean is on waste reduction in construction process (Abdul Rahman, Wang, & Lim, 2012). When management train workers on the use of the framework, monitor compliance, performance, and improvements through KPI's, and 5S audits, waste resulting from incidents and accidents and from other sources can be eliminated on site and thus the aim of lean which is the reduction of variability and irregularities can be achieved (Howell et al., 2002; Abdul Rahman et al., 2012).

### **5.3.1.3. Technical tools of the LSF (5S, Visual Management, A3/PDCA)**

The other elements in the LSF are the technical tools that management makes use of, to make the sociotechnical work environment safe to work in: 5S, Visual Management, A3/PDCA. These lean construction tools all work together to mitigate accident root causes in the sites. First of these tools is the 5S Methodology, an industrial housekeeping technique used by organisations to maintain safe and quality environment (Ho, 1999).

The 5S methodology uses five steps of sort, set-in-order, shine, standardize and sustain as a continuous improvement cycle to keep the work environment clean and shining, making abnormalities visible including space creation. This is the first technical lean tool the framework applies to the work environment, to be done every day by workers as part of the work system before the start of tasks.

The 5S technical lean tool starts with 'sort'. In this step, workers must sort out materials and tools that are needed for work in the sociotechnical work environment, and those that are not needed. In doing this, Kumar & Kumar (2012) suggest two process to follow: first, the items that are not needed in the work environment must be identified, and red tagged to indicate that these items need to be taken off the work environment. The responsibilities for this fall on the employees; second, the red tagged, not needed items would need to be evaluated and disposed. Therefore, there need to be a 5S holding area created for the disposition and evaluation. Responsibility for this lay on the managers. The essence of the sort stage is for stratification management (Kumar & Kumar, 2012). This stage helps to get materials that are not needed out of the sociotechnical work environment and will help workers find causes in the worksite before they become problems.



The set-in-order step is to arrange what is needed for operation in the sociotechnical work environment, so that everything is ready to be used when needed and the need to start searching for materials and tools are eliminated. In lean this is synonymous with the phrase “every item has a place, and everything is in its place” (Poornima, 2011). The focus of this stage is on good organisation of the sociotechnical work environment, neatness within the work environment, search elimination, prevention of mistakes, time reduction from searching for materials, avoidance of accidents resulting from lack of adequate space for all operations, and functional management of the sociotechnical work environment (Poornima, 2011; Kumar & Kumar, 2012). This stage helps to eliminate accidents resulting from slips, trips, and falls, accidents resulting from lack of space, accidents resulting from using the wrong tools because the right tools cannot be found, etc. It helps structure the behaviour of employees towards good workspace organisation skills, and towards neatness.

The shine stage of the 5S when applied in the sociotechnical work environment helps to maintain standards and identify defects. This step involves thoroughly cleaning the sociotechnical work area and equipment regularly in a way that everything is returned to nearly new state. In this step, employees should be taught how to regularly get rid of waste, grime, foreign bodies, and clusters both hidden and visible in the sociotechnical work environment. In doing these, both hidden and visible hazards can be spotted and eliminated, defective machines can be spotted and taken out for repairs etc. This stage lays emphasis on cleaning as a means of inspection, and on a sociotechnical work environment that is impeccable and clean.

These first three stages of the 5S methodology, combined with the last two stages under the control of management: standardize and sustain, contributes towards eliminating all the identified root causes in this study and are in line with previous studies that have applied the 5S and visual management in construction projects for safety improvements and performance (Mastroianni & Abdelhamid, 2003; Salem et al., 2005; Leino et al., 2014; Enshassi & Zaiter, 2014; Tezel & Aziz, 2016; Marhani et al., 2018).

The next technical lean tool applied after doing 5S is the Visual Management tools. Visual management refers to a way of communicating information using the right visual tools, at the right time, for the right situation in all construction projects (Abdelkhalek et al., 2019). Such visual tools can be warning signs, caution signs, posters, and many more. For example, where abnormalities have been spotted in the worksite after application of the 5S, visual tools like

warning signs or caution signs can be placed around the abnormalities to warn people about the danger ahead so they do not become accident victims.

When abnormalities or hazards are created while the task is going on visual signs can be placed to warn about such dangers as the task continues. Safety slogans can always be placed around the worksites to remind workers about acting and behaving safe. Importantly, when visual tools are placed on site, they help with communication of important safety instructions, and this is a major factor for maintaining a safe construction work environment (Awada et al., 2016). The major principle behind visual management is that people are usually attracted by what they see (Ho, 1993). These tools are to be placed in all potential danger zones around the work site. Because they are information and communication tools, they influence behaviour by catching people's attention and delivering message for action (Bust et al., 2008; Tezel et al., 2015). Furthermore, the use of visual management in the sociotechnical work environment helps to improve transparency on site (Brady et al., 2012).

Combined with the 5S methodology, visual management through its visual awareness warning signs increases safety security in the sociotechnical work environment and makes the work environment a haven to work in for employees. These two technical tools combine effectively to identify and eliminate hazards before they lead to accidents, spot abnormalities, create knowledge awareness, makes the work environment clean and safe to work in, and increase safety performance (Abdelhamid & Salem, 2005; Falkowski & Kitowski, 2013). When applied in the sociotechnical work environment, they combine well to eliminate the root causes of accidents identified in this study.

The last technical lean tool in the framework is the A3/PDCA problem solving tool. The A3/PDCA problem solving framework is a framework that organisations can employ to diagnose the root causes of problems and to provide countermeasures to solve the problems (Shook, 2008). For example, after doing the 5S on site and applying visual signs, and accidents persist, the A3/PDCA can be made use of by management to diagnose the underlying reasons behind the accidents. The 5Y root cause analysis tool and the fishbone diagram in the A3/PDCA continuous improvement/diagnostic tools can help construction organisations trace accidents or problems to their root causes. This can then lead to further improvement strategies because the main goal of the PDCA is to continually improve work process.

The above paragraphs spell out and describes the Lean Safety Framework as represented in Figure (10) below. It is expected that the holistic application of this framework in construction process by construction companies in Nigeria will help these companies to mitigate accident root causes.

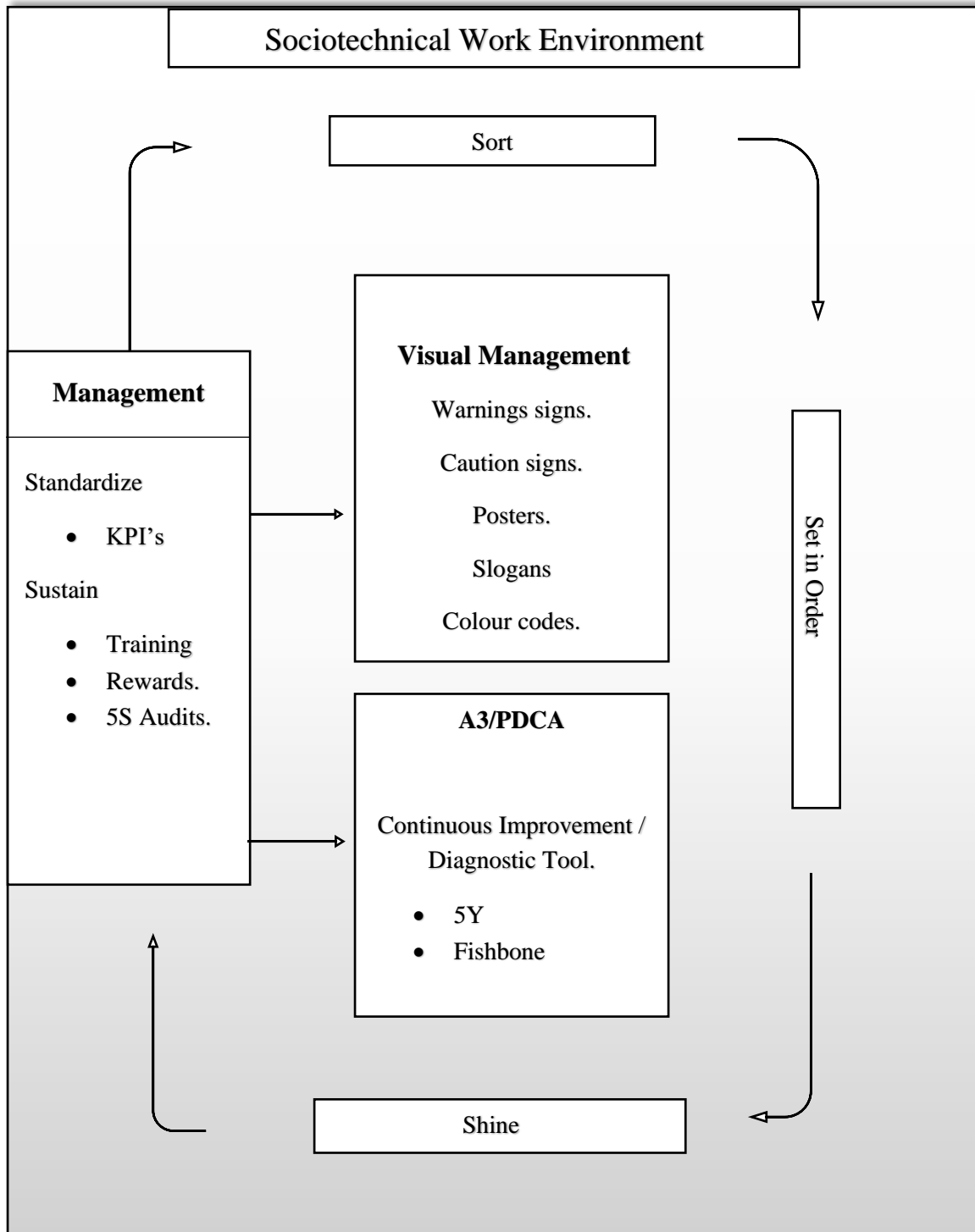


Figure 10 Lean Safety Framework. (LSF)

### **5.3.2. Implications for existing and future National and Organisational Policy**

This research has implications for existing and future national and organisation policies. Policies exist to guide decisions and achieve national outcomes through their implementations. In construction safety and others, government and organisational health and safety policies sets out the general approach to health and safety and the ways employers can manage health and safety in their businesses.

Present national health and safety policy by Government in Nigeria have their objectives channelled towards the improvement of working conditions and the work environment, prevention of accidents resulting from the course of work, and provision of safety and health services to workers (Federal Republic of Nigeria). In England for example, present government policies on health and safety require every business that have five or more employers to write down safety policies (HSE, 2020). In parts, the policy covers areas such as roles and responsibilities and practical arrangements such as having frameworks for doing risk assessments, training of employees, use of safety signs, provision of personal protective equipment.

Based on findings from this study, the construction industry in Nigeria has a poor health and safety history. While there are policies in place, compliance by construction organisations to these policies, are almost zero and companies complain that health and safety is expensive. Hence in the country, many indigenous construction organisations do not invest in health and safety. Training of employees on safety are low, and risk assessment frameworks for accident prevention are hardly available and utilized.

Having noted the above, the elements that make up the Lean Safety Framework created through this research are all lean tools that are cheap to implement. Therefore, for construction organisations both within Nigeria and outside the country that want to work in line with meeting up the objectives of their present and future national and organisational health and safety policies, the Lean Safety Framework can be an effective framework for risk assessment and accident prevention when implemented and will serve the better good of construction organisations implementing it through creating a work environment that is clean, accident free, and safe to work in for employees.

Importantly, proper, and effective implementation of the Lean Safety Framework on site can bring relatively quick results to construction organisations implementing it who want to make a difference in their business. This will help construction organisations meet up with their policy objective of improving work conditions and providing safe work environment.

Furthermore, the results of implementing the Lean Safety Framework in construction sites can be easily observed through the cleanliness of the work environment using the 5S technique, availability of safety signs in danger areas within the worksites where warning signs are required. Therefore, for government visitors to the sites where this framework would be implemented checking for compliance with policies, the application of the framework can be a way to adhering to policies and working in line with national policy guidelines.

The implementation of the Lean Safety Framework by construction organisations requires that HSE officers who use their skills and knowledge to promote a positive safety culture are employed to lead the implementation. HSE officers by nature of their job ensure that safety policies, legislations and practices are adopted and observed. They ensure safety on the site and work with frameworks to achieve target goals of preventing accidents. This will have an impact on both national and organisational policy.

## **5.4. Chapter Summary**

This chapter has discussed the findings from this study following the structure of the objectives set out to answer the research question. The discussion focused on the three main sections as set out in the objectives of the study. The first section discussed “the root causes of accidents in the Nigerian construction industry. In this section, the five main root causes identified in the study were discussed in-depth. The second section discussed how and to what extent lean tools such as 5S, Visual Management and the A3/PDCA can be used to mitigate the five identified root causes of accidents in the Nigerian construction industry. Here, the in-depth discussions focused on each of these tools vis-à-vis their contributions towards mitigating the various root causes identified. The third section focused on objective three, which is the core contribution of this study. The goal of this section was to develop a safety framework that construction firms can make use of to mitigate accident root causes. The Lean Safety Framework (LSF) was developed and an explanation of how the framework can be made use of to mitigate accident root causes was outlined. The next chapter will conclude the study by highlighting the relevant issues in the study i.e. a review of the main objectives of the study, a summary of the main findings of the study, recommendations, research contributions, and ends with a discussion of the limitations of the study and future research.

## **6. Chapter Six – Conclusion**

This chapter concludes the research. It takes the readership back to the main objectives of the study and how these were achieved. It also presents the key findings of the study including the main conclusions, recommendations, research contributions and limitations. The chapter ends with the direction for future studies.

### **6.1. Review of the Original Research Objectives**

In the chapter one of this research, three different objectives were set out to provide answer to the research question asked in this study. The research objectives are:

1. Investigate the root causes of construction accidents in the Nigerian Construction Industry.
2. Explore how and to what extent lean tools such as the 5S, Visual Management, and the PDCA/A3 can be used to mitigate these root causes.
3. Develop a conceptual lean framework to allow organisation to diagnose and improve health and safety performance.

To achieve objective one of this research, a literature review was first carried out to understand the health and safety issues facing the Nigerian construction industry. From this review it was discovered that the country lacked its own statutory health and safety regulations for construction and operated more on borrowed legislations from England, which were not so practicable in Nigeria. It was also discovered that even the few legislations made by the federal government lacked proper enforcement by the body in charge of enforcing non-compliance. Due to this, a lot of construction organisations and contractors in the country do not comply with the regulations. Invariably, this has resulted in the poor level of health and safety performance in the country especially with indigenous companies leading to various levels of accidents. Statistically, it was revealed that the country lacked records to show accident statistics. However, the review pointed to a few reported accidents by newspapers and by some academic studies in the country. Furthermore, review was carried out on the root causes of construction accidents from previous studies across different safety research and these root causes were summarised into seven identified root causes. These were lack of knowledge and training, non-provision of safety equipment and materials, workers attitude and behaviour,

deficiencies with enforcement of safety, lack of safety management, working long hours and overtime, and workplace factors such as poor housekeeping, space availability, space layout, dirty and hazardous environment. Then to fulfil the main objective, a qualitative data collection method was devised, paving way for a semi-structured interview that was conducted in Nigeria to identify the root causes of construction accidents in the country. Findings from this identified five main root causes. These are:

1. Lack of information, knowledge, and training.
2. Inability to identify or recognise hazards/unsafe conditions in the worksite before the start of tasks.
3. Identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition.
4. Management failure to provide safe work environment.
5. Negative behaviour and attitude towards safety by workers.

These five accident root causes satisfied the objective one of this study, which was to find out the root causes of accidents in the Nigerian construction industry.

Furthermore, the objective two of the research was to explore how and to what extent lean tools such as the 5S, Visual Management, and the A3/PDCA problem solving framework can be used to mitigate the root causes of construction accidents identified in objective one. To achieve this, a comprehensive literature review was carried out on lean thinking and lean construction. The review looked at such areas as lean thinking, the principles of lean thinking and how lean was introduced to the construction industry from the manufacturing industry. It was highlighted that lean is a management technique with a focus on waste elimination and continuous improvement. Since waste is seen as anything that absorbs resources but does not add value, construction accidents were therefore classed as waste because they absorb resources, take life, incapacitate, and add no value to construction process. Therefore, the study further reviewed the various available lean construction tools that companies can make use of to achieve their goal of eliminating these wastes. Some of these tools like the 5S Methodology, Visual Management, and A3/PDCA focus on safety. These tools were chosen for this research and more detailed review was carried out on each of these tools, including their successful implementations in construction projects and barriers. Furthermore, semi-structured interview was made use of to gather qualitative data from indigenous construction companies in Nigeria to find out the safety management systems they make use of, if they know about lean, and what



they think about the lean construction tools for this study, and if these tools can mitigate accident root causes. Part of the interview involved participants watching short clip videos of each of these tools. From the literature review and interviews findings, the how and to what extent these tools can help mitigate accident root causes were established. It was outlined that the application of these lean tools in the Nigerian construction industry will help to mitigate the identified accident root causes in construction sites in the country. This therefore satisfied the objective two of this study.

Based on the above knowledge, the objective passed focus to the third objective. which is to develop a framework that construction companies can make use of to diagnose and mitigate accident root causes. To achieve this the study took into consideration the discussions on objective one and two. Based on the outcome of this discussion, the study combined the three lean construction tools for the research to successfully create a framework that takes the social, organisational, and technical aspect of the construction work environment surrounding the workers into perspective. This framework is termed the Lean Safety Framework (LSF), see Figure 10. The successful creation of the LSF helped to fulfil the third objective. Thus, by applying the LSF, which a lean safety system in construction process in the Nigeria Construction Industry, accident root causes can be mitigated. The research objectives are summarised in table 11 below.

*Table 11 Research Objectives Summary Table*

<b>Research Objectives</b>	<b>Achieving the Objectives</b>
1. Investigate the root Causes of Construction Accidents in the Nigerian Construction Industry	Five root causes were identified in the Nigerian Construction Industry: <ol style="list-style-type: none"> <li>1. Lack of information, knowledge, and training.</li> <li>2. Inability to identify or recognise hazards/unsafe conditions in the worksite before the start of tasks.</li> <li>3. Identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition.</li> </ol>

	<p>4. Management failure to provide safe work environment.</p> <p>5. Negative behaviour and attitude towards safety by workers.</p>
<p>2. Explore how and to what extent lean tools such as the 5S, Visual Management, and the PDCA/A3 can be used to mitigate these root causes.</p>	<p>The study found that lean construction tools such as the 5S, Visual Management, and the A3/PDCA Continuous improvement and problem solving tool can all individually contribute towards mitigating the identified accident root causes in objective 1, and can be combined in a single safety system as a safety framework to mitigate the identified root causes.</p>
<p>3. Develop a conceptual lean framework to allow organisation to diagnose and improve health and safety performance</p>	<p>Based on the findings of objectives 1 and 2 above, a Lean Safety Framework (LSF) see figure (9) was developed that construction organisations can apply to in within their organisations to diagnose and improve their health and safety performance and thus save workers from incidents and accidents, sickness and death as the perform their daily tasks on sites in the Nigerian construction industry.</p>

## 6.2. Summary of Main Research Findings

One of the objectives of this research was to find out what the root causes of accidents are in the Nigerian construction industry. Findings from the study identified five main root causes. The first root cause identified was lack of information, knowledge, and training. It was found in the study that majority of the indigenous construction firms in the country do not provide training for their workers when they are employed. Because they lack health and safety

training, it is difficult for them to understand hazards when they see them. It is difficult for them to differentiate safe acts from unsafe acts. Thus, the outcome is that they end up being the direct cause of accidents. The second root cause of accidents identified was inability of workers to recognise hazards/unsafe conditions in the worksite before the start of task. It was discovered that majority of these indigenous construction firms do not have risk management techniques that they make use of to identify hazards in the worksites before the start of tasks. Of the three small-scale construction companies that participated in the research, only small-scale company three had risk management techniques. They make use of the Job Safety Analysis (JSA) to identify hazards in their worksite before the start of each task. The other two small-scale companies have no hazard identification technique and thus go straight to the job. Of the three medium scale companies that participated, two are sub-contractors to multinational companies and thus make use of the safety management system of the companies. They make use of the JSA as well as other tools like the TSTI, TSTO, PPHA, etc. However, the third medium scale company, which is a road construction and repair company in the state has none. Like the other two small scale companies, they go straight to the job. The outcome of this is that when they cannot identify hazards and eliminate them before the start of tasks, they end up becoming victim of accidents resulting from those hazards. The third root cause identified was identifying hazards/unsafe conditions and continuing to work without first eliminating the hazards/unsafe condition. It was discovered that many times workers recognise the hazard or unsafe condition in the worksite but rather than stop work and take care of it, they ignore it and continue with the job, thus accident occurs. The fourth root cause identified was management failure to provide safe work environment. It was found that the site condition of many indigenous construction companies in Nigeria are bad thereby making these sites unsafe to work in. However, it is the duty of management to provide a safe work environment for the workers. Thus, when they do not, workers generally work in and around hazards and thereby become victims of accident emanating due to the hazards and unsafe conditions of the work environment. Finally, the last root cause identified was negative behaviour and attitude towards safety by workers. Some factors that can lead to this were identified as lack of education. Under this factor, it was found that majority of the labour workers who carry out the main construction work in the field for most indigenous construction firms in the country have little or no formal education. Coupled with this, majority of these workers also do not have professional training with respect to the job. Another factor found was failure to follow safety procedure. Under this factor it was discovered that some workers would refuse to wear safety equipment even when

they are provided with it. Another factor was use of drugs and alcohol by workers before work. It was discovered that this is a usual occurrence on site in Nigeria with one of the accident examples validating this. The influence of social and organisational factors was also stated to be a factor for this. Then also performance pressure and overconfidence by workers. These findings were noted to be in line with previous studies. See section 5.1.

Another objective was to explore how and to what extent lean tools such as the 5S, VM, and A3/PDCA can be used to mitigate accident root causes. First the study found that lean awareness in Nigeria is low. Also, findings from the study suggest that each of these tools can in their own way contribute to mitigating the accident root causes identified in this study. It was found that the 5S through its five steps of sorting out the tools and materials in the working worksite and getting rid of unwanted materials, setting the needed materials in order and using colour codes to label them for easy recognition when they are needed, shining the work area, tools, and materials to make the worksite clean, transparent and free from hazards, to standardizing and sustaining the previous steps would contribute to mitigating all the root causes identified in the study as shown in Figure 6. Furthermore, the findings also suggest that using visual tools like signages and posters in the worksite can contribute to mitigating some of the root causes identified as shown in Figure 7. This is because when signs are placed in strategic places in the worksite, they warn people about potential dangers and hazardous locations, influences and directs people's behaviour and communicate important messages and instructions to the workforce, even when the managers, supervisors, safety officers are not there to speak. Further findings suggest that the A3/PDCA problem solving framework can help indigenous construction companies in Nigeria to diagnose the root causes of accidents. Presently, the findings suggest that some indigenous construction companies in the country do not have tools for problem solving. This tool would go a long way with helping these companies diagnose and solve problems.

### **6.3. Recommendations**

Commitment to safety is a big issue in many indigenous construction companies in Nigeria both at the small and medium scale levels. Without commitment the goal of achieving an accident free workplace cannot be guaranteed. Hence, the study recommends that companies that want to make use of this proposed Lean Safety Framework (LSF) must first be committed

to safety at both management and labour level, because commitment is the driver that will lead to the effective use of the (LSF). Furthermore, the Lean Safety Framework is one that cannot just be implemented without training employee on its use. Therefore, companies must invest in proper training of their staffs both management and labour on the lean elements that make up this framework: 5S, VM, A3/PDCA, and how the framework works before embarking on using the framework. It is important to understand that the Lean Safety Framework is not made with concrete, therefore it is open to further improvements. So, as construction organisations make use of the LSF, they should continually adjust on it if such adjustment lead to continuous improvements. Lastly, some of the companies that participated in this research faulted the reason for their poor performance to safety on finance, stating that health and safety is expensive. Lean as a management technique is not expensive to achieve. To make this even leaner, this research has put together three core lean safety tools to create this LSF. Therefore, it recommended that companies adopt this framework because overall, the application of the LSF will help mitigate accidents, save money, and make jobs organised and quicker to accomplish.

## **6.4. Research Contributions**

The contribution of this research is in two forms: contribution to theory, and contribution to practice. Nicholson et al. (2018) outlined various strategies to articulating contributions to what is theoretically known. One of such strategies as it relates to this thesis is the incremental contribution, which is based on traditional gap spotting approach. This approach is applied in the contribution to theory below.

### **6.4.1. Contribution to Theory Development**

Despite the various body of research that has investigated safety in construction with end goals of creating solutions to end the scourge of accidents in the industry, accidents still occur. While it is safe to say that research will continue to look for ways to end this dilemma, it is evident that conventional efforts in dealing with workplace safety are insufficient in accident prevention and the body of knowledge is in need of a framework that deals with this serious issue to close the gap. A major reason for this insufficiency has been that these efforts focus

more on the individuals and does not take the broader sociotechnical aspect of the work environment into perspective. It was therefore advised that focused be placed on the broader context of work such as the social and organisational aspect of the work environment and the technical aspect (Carayon et al., 2015). Hence this study incorporated the sociotechnical systems theory as a theoretical lens to investigate this issue. By applying the sociotechnical systems theory, the author was able to develop a more holistic, fine-grained lean safety framework (LSF) that provides greater insights into workplace safety taking the broader social, organisational, and technical aspect of the construction work environment surrounding the workers into perspective. This study has helped in covering the gap created by conventional methods identified in this study by focusing on not only the individuals but also on the work environment, and tools and techniques the individuals make use of to stay safe while carrying out their construction activities on site and also by creating a safety framework (see figure 9) for this purpose. Thus, the study has shown that by applying the sociotechnical systems theory to harmonize the social, organisational and technical aspects of the construction workplace, accident root causes can be mitigated and therefore, health and safety can be improved to a great extent. This is consistent with the sociotechnical systems theory discussed in chapter 2 (Mumford, 2006). Furthermore, the study developed and presented a framework (LSF) based on the sociotechnical theoretical lens, supported by case study interviews and non-participant observations. Therefore, this study has expanded the use of sociotechnical systems theory by using the theory to detail how lean practice can be applied in safety systems to mitigate accident root causes in construction and providing a framework that explains how this can be achieved.

#### **6.4.2. Contribution to Practice**

While there have been studies in Nigeria focusing on improving health and safety in construction, it is noteworthy to state here that such focus has never been centred on lean. Being a profit maximization and waste elimination technique, lean through some of its tools and technique have the potential to improve health and safety in the country's construction industry if applied as this study has established through the LSF development. This is not to say that lean has not been applied in construction and other fields in the country even though the concept is new to the country. Authors like Adamu et al. (2012) and Ahiakwo et al. (2013) have implemented the Last Planner System (LPS) for improvement of construction practice in the country. However, no prior studies on lean in a Nigerian context have investigated how lean

can be used to prevent accidents and unsafe practices in the construction industry to the knowledge of this researcher. Therefore, this research covers this gap by taking the first step to contribute to the practice of lean construction and health and safety in Nigerian construction. This has been achieved by the development of the practical Lean Safety Framework (figure 9) for organisations to make use of in improving their health and safety performance.

## **6.5. Theoretical and Practical Implications**

### **6.5.1. Theoretical Implications**

The thesis has demonstrated that workplace safety issues are multifaceted. It has also demonstrated that to deal with this multifaceted issues, focus can be placed on the broader context of work, namely, the social, organisational, and technical environment: a sociotechnical systems theory stand, as against just the individuals which traditional efforts previously placed focus on (Carayon et al., 2015). Hence, the study incorporated the sociotechnical systems theory in a safety system through development of the Lean Safety Framework in figure 10. This has theoretical implications. Through the incorporation of the sociotechnical systems theory in the Lean Safety Framework, the application of the framework in a construction or manufacturing work process will help these organisations to take care of workplace safety issues on a more broader level, and thus, accidents can be reduced, prevented, if not completely eliminated on site. Furthermore, the Lean Safety Framework can perhaps add to previous research on ergonomics and the sociotechnical systems theory body of knowledge, leading to further research on interesting and promising areas of workplace safety research and lean.

### **6.5.2. Practical Implications**

The Lean Safety Framework is important and have practical implications for construction firms, and in construction safety research in Nigeria for several reasons. First, previous research has shown that safety research in the Nigerian construction industry lack available framework for accident prevention (Williams et al., 2018). This study has provided a framework through development of the LSF to cover this gap in the construction safety research body of knowledge in Nigeria. Thus, safety research in the country will benefit from this study as the study will be useful for the authors of academic journals, conference papers, and for both undergraduate and

post graduate researchers in the country. It will also be useful to undergraduate and post graduate researchers outside the country writing papers on improving construction safety in Nigeria.

Furthermore, the developed LSF will also be beneficial to construction organisations in Nigeria at all indigenous level. This is because if applied in a safety system and successfully implemented, the LSF can perhaps be a useful framework that constructions firms in the country can practically apply to mitigate accident root causes on site, improve safety performance, increase workers' wellbeing, while saving cost, thereby maximizing profit for the firms.

Also, for construction managers, the LSF will be useful in managing and keeping the workers and worksite safe and free of hazards. To achieve this, construction managers should apply the LSF on site before the start of projects and while projects are on-going and must diligently do so, following the laid down structure and use of the LSF. The LSF will therefore be a guide that management of construction firms in the country can make use of to prevent accidents and to improve health and safety performance in their worksites.

## **6.6. Research Limitations and Future Research**

There are a few limitations that underpins this research, which also offer fruitful future research avenues.

Because of the intricate nature of health and safety, it was particularly difficult getting companies to participate in this research. Several companies were emailed in Nigeria from the UK, but none responded. Upon getting to Nigeria, several companies were approached, both multinational, and indigenous construction companies (small-scale and medium scale). Only six companies agreed to participate: all indigenous companies. The initial plan was to have two multinational companies, two medium scale indigenous companies and two small-scale indigenous companies as the case studies companies for the research. This is so that the root causes of accidents can be viewed from three different perspectives. Especially with having the understanding that the multinational construction companies value health and safety and as such give it a priority and are engaged in bigger construction projects as against the indigenous companies' majority of whom literature suggest do not give safety a priority in the country and



are engaged in smaller projects. Therefore, it would have been interesting to understand the views of the multinational companies about accidents and their root causes, what they do to protect the health and safety of their workers, and to know the safety management systems they operate with, including understanding their views about the lean tools made use of for this research. This would have helped to capture different dimensions of the issue in question and enable comparisons and similarities to be drawn, as well as providing the chance to have a wider and more quality discussions. However, none of the multinational companies approached agreed to participate. To compensate for the two multinational companies, the researcher therefore expanded both the small-scale and medium scale indigenous companies to three each with two of the three medium scale companies being sub-contractors to multinational companies. However, this still limits the study to just indigenous companies. Thus, future research should consider investigating this phenomenon in multinational construction companies in the country.

It would have been very beneficial to this study if the researcher is able to get access to the health and safety documents of the companies that participated in the study. This would have helped to provide more support and strengthen the argument in the research topic. It would have also helped as another source of triangulation and as well as helping to improve the construct validity of the research. However, due to the sensitivity and seriousness of health and safety issues, the companies refused to grant the researcher access to these documents. This therefore limited the data used for the study to just semi-structured interview data and non-participant observation data. Therefore, it would be important for future study to consider the use of document analysis data to further strengthen and enrich the findings of the study. Furthermore, the study is limited to only three lean construction tools: 5S Methodology, Visual Management, and the A3/PDCA Problem Solving Framework. This is not to say there are just three lean construction tools that can be used for safety purposes. There are other tools like the last planner system, fail safe for quality and safety, poka-yoke that have safety elements in them. Further study could therefore as a way of enhancing the lean safety framework developed in this research, look for ways of maybe incorporating one or some of these other tools in the LSF.

Testing the Lean Safety Framework on some construction projects in Nigeria to see how effective it would work would have been fruitful. But because of the time limit for the research and the distance between Nigeria, which is the study context and the United Kingdom where

the research was conducted, coupled with financial difficulties and other issues, it was impossible for the researcher to travel to and from Nigeria to test the efficacy of the Lean Safety Framework (LSF) on construction projects in Nigeria. This has put some limitation as to the effectiveness of the framework. To make up for this, the researcher hopes to focus on testing the framework in some construction projects in Nigeria as his next post-doc focus. Contacts are already being made to this effect. However, this does not stop others from testing the LSF in construction projects in Nigeria. Therefore, future research should focus on a quantitative study to test the efficacy of the LSF developed in this research on construction projects in the country for further enhancement. Furthermore, since the root causes of construction accidents found in this study may be similar with those from other developing countries like Ghana, Cameroun, Liberia, Niger, etc who share similar characteristics as Nigeria, a quantitative study to test this framework could also be conducted in these countries to test and enhance the framework.

Finally, while this study is limited to just construction companies in Nigeria, lean thinking however originated from the manufacturing sector. As such, the tools applied to develop the Lean Safety Framework in this study are also tools applied in Lean Manufacturing, which were borrowed from manufacturing and has individually been proved to improve safety in this sector. It would therefore be interesting to see how this framework would react in factory settings. Therefore, future research could also look in the direction of testing the Lean Safety Framework in the manufacturing sector in Nigeria as a way of contributing to theory and practice in the lean manufacturing field.

## **6.6. Chapter Conclusion**

This chapter has reviewed and highlighted the three main objectives of the research with a view to providing answers to the research question. The chapter also presented a summary of the main research findings. Further, the chapter presented the recommendations of the study, the research contributions to both theory and practice, and practical and theoretical implications were discussed. The chapter ended with a discussion of the research limitations, including recommendation for future study.

## **6.7. Reflective Commentary**

Considering that the first and second degrees of the researcher were all in IT, this PhD thesis has helped the researcher in a great way in having deep understanding and experience about lean construction, construction safety and the sociotechnical systems theory, all in the management field. Through this journey, the researcher was able to build deep knowledge on health and safety in the Nigerian construction industry, the reasons for accidents and on the concept of lean thinking and lean construction, which were new to the researcher before the commencement of this journey. Furthermore, the research gave the researcher the opportunity to gain deep knowledge about the sociotechnical systems theory and how this theory and others can be applied in management research. Importantly, this research has made the researcher gain more knowledge in research methods and about different research philosophies, research designs, including analytical techniques and how to apply them in my future research designs. The knowledge gained writing this thesis is very important for the researcher for the future especially with his interest in academia. It has helped to shape his ideas, critical thinking ability, and his academic writing skills in the search for, and dissemination of knowledge. Therefore, for the future, this research has created a solid foundation for the researcher to stand and build on in his pursuit of academic excellence.

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# Appendices

## Appendix 1: Data Collection Cover Letter

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**2013**  
**THE AWARDS**  
AWARD WINNER  
UNIVERSITY OF THE YEAR

03/08/17

**Student Name – Kelvin Egbele-Okoro**  
**Reference - 1375875**

To Whom It May Concern

Kelvin is registered at the Huddersfield Business School, University of Huddersfield on the PhD (Business and Management) Programme.

He is undertaking necessary fieldwork towards his research project and we would ask that you provide him whatever support and access you can to enable him to conduct his study.

If you require any further information do please let me know.

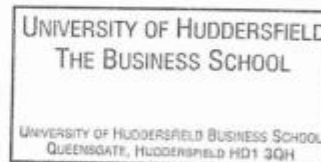
Yours faithfully,



**Martin Smith**  
**Post Graduate Research Administrator**

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## Appendix 2: Semi-Structured Interview Questions

### Examining Health and Safety through the Lean Thinking Lens: The Case of the Nigerian Construction Industry

#### Accidents and causes, including root causes.

##### A. ACCIDENTS

- What are the main reasons for accidents on site?
- In your experience as a construction worker, what are the various types of accident you have seen occurring on site?
- Slips, trips, and falls, lifting and handling, falls from height, and struck by object are some of the most common accidents that happen daily in the construction industry. Why are these kinds of accident so common in construction?
- Are there procedures for reporting accidents in the country?
- Who do you report to and what are the procedures for reporting?

##### B. ROOT CAUSE

- In your own terms, what would you say are the root causes of construction accidents?
- How do you trace an accident to its root cause?
- Could you give me examples where an accident had occurred to you or your co-workers on site?
- Were investigations conducted to ascertain the root causes of the accidents?
- What were the root causes of the accident you investigated?
- In investigating accident, scholars have stated that:  
Failing to identify an unsafe condition that existed before an activity was started or that developed after an activity was started,  
Deciding to proceed with a work activity after the worker identifies an existing unsafe condition and deciding to act unsafe regardless of initial conditions of the work environment, are the root causes of construction accidents. What are your thoughts about these statements?

##### C. MANAGEMENT ACTION

- As management, what safety procedures do you guys have on ground to check for hazards before they become accidents on site?
- What role do you think you can play in improving health and safety of workers?
- How does your organisation approach risk on site?
- Before commencing a construction project, does your organisation sit to consider the various health and safety risk that could be associated with the project?
- Do you think that if management are able to carry out thorough risk assessment before the start of jobs, hazards can be identified and eliminated before they become accidents leading to injury?

- Can you show or explain to me an example of an instance where you have made use of the risk management plan?

### **LEAN QUESTIONS**

• Have you heard of the following lean tools; 5S, (A3, PDCA), and visual management? I have three (3) videos to play for you now on the listed tools, after watching each of these videos, I would ask you some questions based on the videos.

#### **5 S Questions.**

- What do you think about the 5S process?
- Have you ever used it or seen it being used?
- Has your organisation made use of the 5S or a similar tool?
- If you were given the 5S to do, how would you feel?
- Does your organisation have a management tool for accidents prevention?
- What are your thoughts about the 5S being a tool that could make the workplace well organised, spacious, easier to work in, and accident free?
- Do you see yourself using this tool if given the chance to by your organisation?
- Would you recommend this tool?
- What do you particularly like about this tool?
- Do you think if implemented, this methodology can be maintained and made a part of your organisations business culture?

#### **Visual Management Questions.**

- What do you think about using visual signs as a safety tool to inform workers what to do and warn people about hazards in the worksite?
- Have you ever made use of this tool or seen it being used?
- Has your organisation ever made use of this tool or a similar tool?
- If for instance you are given this tool to use in your work site, how would you feel using it?
- What are your thoughts on the process of using the visual signs?
- How do you see this tool, in terms of accident prevention on site?
- Do you see yourself making use of this tool in your work site if given the chance to by your organisation?
- Tell me what you like about this tool.
- Would you recommend this tool to your organisation?

#### **Systematic Problem-Solving Framework.**

- How does your organisation solve problems when they arise (Do you have a framework you make use of)?
- What do you think about approaching work using a systematic problem-solving framework like the A3/PDCA tool?

- Do you think achievement of small incremental changes in processes can improve efficiency, quality, and safety?
- Do you see this tool as one that can be used to continually improve the safety program of organisations?
- What problem solving tool does your organisation use?
- Have you made use of this tool or a similar tool before?
- Do you think the A3/PDCA if properly carried out, can help organisations detect problems and their root causes within the workplace and therefore help to reduce/eliminate accidents?
- Would you make use of this framework in your organisations if given the chance to?
- Would you recommend this tool?

**END**

## Appendix 3: Research Consent Form



### CONSENT FORM

#### **Examining Health and Safety through the Lean Thinking Lens: The Case of the Nigerian Construction Industry**

It is important that you read, understand, and sign the consent form. Your contribution to this research is entirely voluntary and you are not obliged in any way to participate. If you require any further details, please contact your researcher.

I have been fully informed of the nature and aims of this study as outlined in the information sheet version 1, dated .....	<input type="checkbox"/>
I consent to taking part in this the study	<input type="checkbox"/>
<p>I understand that I have the right to withdraw from the research.</p> <p>You have the right to withdraw or withdraw any data you have provided from the research process at any stage of your direct participation provided that such withdrawal is feasible.</p> <p>However, at certain stage of the research such withdrawal may no longer be feasible.</p> <p>Example of such stages will be:</p> <ul style="list-style-type: none"> <li>• Where your responses/data have been pooled with other responses.</li> <li>• Where you have been anonymized.</li> <li>• Where results have already been published.</li> </ul> <p>In these cases, it may no longer be possible to extract your data.</p>	<input type="checkbox"/>
I give permission for my words to be quoted (by use of pseudonym)	<input type="checkbox"/>
I understand that the information collected will be kept in secure conditions for a period of 3 years at the University of Huddersfield.	<input type="checkbox"/>
I understand that no person other than the researcher/s and facilitator/s will have access to the information provided.	<input type="checkbox"/>
I understand that my identity will be protected using pseudonym in the report and that no written information that could lead to my being identified will be included in any report.	<input type="checkbox"/>

If you are satisfied that you understand the information and are happy to take part in this project, please put a tick in the box aligned to each sentence and print and sign below.

Signature of Participant:	Signature of Researcher:
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<hr/> Print: <hr/>	<hr/> Print: Kelvin U. Egbele-Okoro <hr/>
Date: <hr/>	Date: <hr/>

(one copy to be retained by Participant / one copy to be retained by Researcher)

## Appendix 4: Research Participant Information Sheet



### **Examining Health and Safety through the Lean Thinking Lens: The Case of the Nigerian Construction Industry**

#### **Participant Information Sheet**

You are being invited to take part in a research project/assignment. Before you decide it is important for you to understand why this research is being done and what it will involve. Please take time to read the following information and discuss it with others if you wish. Ask if there is anything that is not clear or if you would like more information. May I take this opportunity to thank you for taking time to read this.

#### **What is the study about?**

The research project is intended to provide the research focus for my PhD in business and management studies. The research examines health and safety issues within the Nigerian construction industry using a lean perspective. This research will at the end provide a lean safety framework to allow organisations improve health and safety performance.

#### **Why have I been approached?**

You have been approached because you work in the Nigerian Construction Industry and as such understand the happenings in the industry especially with issues pertaining to health and safety.

#### **Do I have to take part?**

Participation in this study is entirely voluntary, so please do not feel obliged to take part. If you decide to take part, you will be asked to sign a consent form, and you will be free to withdraw at any time from the study, without giving a reason to the researcher. Refusal will involve no penalty whatsoever.

#### **What will I need to do?**

If you agree to take part in the research, you will be invited to take part in an interview. This should take no more than an hour of your time. The interview will be audio recorded so that the data can be used later for the research.

#### **Will my identity be disclosed?**

All information which is disclosed and collected within the interview will be kept confidential and anonymised before the data is presented in the thesis. This follows the Data Protection Act and ethical research guidelines and principles.

#### **What will happen to the information?**

All information collected from you during this research will be kept secure and any identifying material, such as names will be removed in order to ensure anonymity. It is anticipated that the research may, at some point, be published in a journal or report. However, should this happen, your anonymity will be

ensured, although it may be necessary to use your words in the presentation of the findings and your permission for this is included in the consent form.

**Are there any disadvantages to taking part?**

There should be no foreseeable disadvantages to your participation. If you are unhappy or have further questions at any stage in the process, please address your concerns initially to the researcher if this is appropriate. Alternatively, please contact the research supervisor Dr Benjamin Dehe, Department of Operations Management, Business School, University of Huddersfield. United Kingdom.

**Can I withdraw my consent from the research at any time?**

You have the right to withdraw or withdraw any data you have provided from the research process at any stage of your direct participation provided that such withdrawal is feasible. However, at certain stage of the research such withdrawal may no longer be feasible. Example of such stages will be:

- Where your responses/data have been pooled with other responses.
- Where you have been anonymised.
- Where results have already been published.

In these cases, it may no longer be possible to extract your data.

**What will happen to the results of the research study/assignment?**

The results of this research will be written up in a PhD thesis and presented for assessment in 2019. If you would like a copy, please contact the student.

**Who can I contact for further information?**

The research supervisor is.  
Dr Benjamin Dehe.  
Senior Lecturer in Operations Management.  
University of Huddersfield,  
e-mail: [b.dehe@hud.ac.uk](mailto:b.dehe@hud.ac.uk)

**Name & Contact Details of Researcher:**

Kelvin Uwale Egbele-Okoro  
University of Huddersfield, United Kingdom.  
Email: [kelvin.egbele-okoro@hud.ac.uk](mailto:kelvin.egbele-okoro@hud.ac.uk)



## Appendix 5: Types of Accidents Table

Table 12 Types of Accidents in the Nigerian Construction Industry

<b>Types of Accidents.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Struck by falling object from equipment and tools.	✓	✓	✓	✓	✓	✓
Pierced by nails or sharp object.	✓	✓	✓	✓	✓	✓
Fall from height accidents.	✓	✓	✓	✓	✓	✓
Slips, trips, and falls.	✓	✓	✓	✓	✓	✓
Electrocution accidents.	✓	✓	✓	✓	✓	✓
Laceration accidents.		✓	✓	✓	✓	
Machine failure accidents.		✓	✓	✓	✓	✓
Eye accident from flying particles.		✓	✓	✓	✓	
Fire accident.	✓				✓	
Bruises and pinches.				✓	✓	
Trap between objects.				✓		
Hit by moving vehicle accidents.						✓
Gas Inhalation					✓	
<b>Company experience from Accident Examples Theme.</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Struck by falling object from equipment and tools.	✓	✓	✓		✓	✓
Pierced by nails or sharp object.	✓	✓				✓
Fall from height accidents.		✓	✓			
Slips, trips, and falls.	✓	✓				✓
Laceration accidents.		✓		✓		
Electrocution accidents.				✓		
Fire accident.					✓	

Trapped between object.				✓		
Hit by moving vehicle.						✓