

ANALYSIS OF SAFETY ISSUES IN ROAD  
CONSTRUCTION IN SRI LANKA

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February 2024

## **ABSTRACT**

The construction industry plays a pivotal role in the economic development of any country, with road construction being a key component in enhancing infrastructure. However, the safety concerns associated with road construction projects pose significant challenges that warrant comprehensive investigation. This research report delves into the safety issues prevalent in road construction activities within the context of Sri Lanka.

The study employs a multi-faceted approach, combining literature review, on-site observations, and questionnaire survey with industry executives to identify and analyze the key safety issues in road construction projects across Sri Lanka. 45 construction executives who were involved in road construction projects in Sri Lanka were responded for the questionnaire survey. The study identified several key factors contributing safety of Sri Lankan road construction. These factors are attitudes towards safety, insufficient training, ineffective site management, lack of knowledge among site engineers and technical staff, inadequate provision of personal protective equipment, insufficient attention from top management, and a failure to enforce safety regulations. Based on the findings, allocating funds for safety measures and equipment emerges as the most crucial potential remedy for addressing safety concerns in the Sri Lankan road construction sector. Enforcing penalties for non-compliance with safety measures, offering rewards to companies that prioritize safety in road construction projects, and conducting more safety inspections at road construction sites by authorities all contribute to improving road construction safety in Sri Lanka.

The findings of this research provide valuable insights for policymakers, construction companies, and relevant stakeholders to develop targeted interventions aimed at fostering a safer working environment in the road construction sector in Sri Lanka. Ultimately, the objective is to contribute to the reduction of accidents and fatalities, ensuring the sustainable growth of the construction industry while prioritizing the well-being of its workforce.

Keywords - Road construction, Safety issues, Sri Lanka.

## **ACKNOWLEDGEMENT**

I am deeply grateful to Dr. M. Thayaparan, Senior Lecturer of the Building Economics Department of the University of Moratuwa, for guiding me and providing me with invaluable advice throughout the project especially supervising this work and motivating me to complete this work.

I am grateful to Prof. Nayanathara De Silva, Course Coordinator of the M.Sc. in Occupational Safety and Health Management course at the University of Moratuwa who helped us to enhance our knowledge of Occupational Safety and Health Management. I take this opportunity to thank all the members of staff who imparted the specialized knowledge on the subjects.

Special thanks are to all officials who responded quickly to the research questionnaire and provided unbiased information concerning the study and to all my colleagues who supported me in completing the research during the past year.

Finally, I would like to thank my beloved wife R.M.I.S.Rathnayake, who always encouraged me to pursue my studies during the past 4 years.

## **DECLARATION OF THE CANDIDATE & SUPERVISOR**

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## LIST OF ABBREVIATIONS

ADB	-	Asian Development Bank
GDP	-	Gross Domestic Product
HIRA	-	Hazard Identification and Risk Assessment
ILO	-	International Labor Organization
JICA	-	Japan International Cooperation Agency
RDA	-	Road Development Authority
OSH	-	Occupational Health and Safety
OHSAS	-	Occupational Health and Safety Assessment Series
OHSMS	-	Occupational Health and Safety Management System
OSH&W	-	Occupational Safety Health and Welfare
PAHC	-	Polycyclic Aromatic Hydro Carbons
PPE	-	Personal Protective Equipment
PWD	-	Public Works Department
RII	-	Relative Importance Index
SD&CC	-	State Development and Construction Corporation
TCEO	-	Territorial Civil Engineering Organization
WHO	-	World Health Organization

## CHAPTER 01 – INTRODUCTION

### 1.1 Research Background

In most developed countries, gross domestic product (GDP) significantly depends on the construction industry (Yoon et al., 2013). The Sri Lankan construction sector contributed 7.2%, 6.8%, and 6.9%, respectively, to the GDP in 2017, 2018, and 2019. (Central Bank, 2017, 2018, 2019). The construction sector includes the construction of buildings, roads, bridges, water supply and treatment systems, tunnels, dams, and so on. In recent years, the construction sector has carried out enormous development projects to meet the requirements of the rapidly expanding global population (Awwad, El Souki, & Jabbour, 2016). The writers also emphasized how important the construction industry has grown to be in every economy in order to meet the need for homes, offices, infrastructure, and other services. Also, the construction business generates a lot of employment chances for individuals (International Labor Organization, 2017).

One of the most important aspects of every organization's human resource strategy is ensuring workplace safety (Cheng, Fang & Xie, 2004). The construction business is seen as a setting where a variety of tasks are carried out in extremely dangerous and complicated situations (Skeepers & Mbohwa, 2015). Hence, ensuring worker safety in the construction business is a difficult undertaking (Cheng, Fang & Xie, 2004). Workers in the construction industry are more prone to accidents and occupational illnesses (Raja, Prasad, & Chalapathi, 2015). As a result, when compared to other businesses, the construction industry has the greatest rate of accidents, including fatalities and impairments (Eddie, Cheng & Li, 2004). Construction failures were a major cause of construction accidents (as cited in Eddie, Cheng and Li, Yates & Lockley, 2002). When an accident occurs, many individuals suffer, either directly or indirectly (Omran, Bakar & Sen, 2008). They said that the victims' families and employers suffered the most among those affected. The authors also said that employers suffer because they lose an experienced worker and must bear the incidental costs associated with project interruptions, higher insurance premiums, and medical

expenses. Family members suffer because they lose their loved ones and a source of income.

Workplace safety is a crucial element of every organization's human resource strategy (Cheng, Fang & Xie, 2004). The construction industry is well recognized as a sector where a diverse range of operations are performed under hazardous and intricate conditions (Skeepers & Mbohwa, 2015). Therefore, guaranteeing worker safety in the construction industry is a challenging task (Cheng, Fang & Xie, 2004). According to Raja, Prasad, and Chalapathi (2015), construction workers have a higher likelihood of experiencing accidents and occupational diseases compared to those in other sectors. Compared with other industries, the construction sector has a higher incident rate, which includes both deaths and disabilities (Eddie, Cheng, & Li, 2004). According to Eddie, Cheng and Li, as well as Yates and Lockley (2002), construction mishaps were mostly attributed to flaws in the construction process. According to Omran, Bakar, and Sen (2008), when an accident takes place, there are several persons who experience suffering, whether it is directly or indirectly. The individuals who were most impacted, according to reports, were the family and employers of the victims. The authors also said that firms face negative consequences due to the departure of a skilled employee, including the burden of dealing with project disruptions, increased insurance premiums, and medical expenses. Family members experience hardship as they face the loss of their loved ones and a significant source of financial support.

Transportation plays a crucial part in the everyday living of modern civilization, and industrialized countries already have well-established and efficient transportation networks. Traffic congestion has emerged as a formidable obstacle in emerging nations, significantly consuming time and reducing efficiency, resulting in substantial economic losses (Sadrizadeh et al., 2022). The Road Development Authority (RDA) of Sri Lanka can be considered the pioneer of road construction with planning and designing the road construction procedure within the country. The RDA has planned the future development of the National Highway Network by rehabilitation of the existing National Highways and adding alternate highways to supplement the existing Trunk Road System, so that the capacity of the road network could cater to the future traffic demand. Further, it aims at facilitating greater mobility, shorter travel time and

provides easy accessibility with improved safety to the people (<http://www.rda.gov.lk/>). The introduction of the Southern Expressway (E001) by RDA was a direct response to the transportation needs of the southern and western provinces. This initiative was implemented to fully address the requirements of transportation in these regions. The construction of the southern highway commenced in 2003 and spanned until November 2011, as documented by Elghaish et al. (2022). Subsequently, the national expressway network has officially opened the Colombo-Katunayake Expressway (E003) and Phase I and II of the Outer Circular Highway (E002) for public use. At present, several contractors are engaged in the construction of highway projects (Jiang et al., 2021). During the initial phases of highway development, the contractors involved in these projects were predominantly foreign, with a significant presence from Japan and China. Nevertheless, the aforementioned contracts have recently been granted to local construction firms that possess the necessary financial and technical capacity to meet the stipulated conditions outlined in the contract (Dais et al., 2021). Construction is often regarded as one of the most dangerous industries globally. As complicated projects become more prevalent, there has been a rise in construction accidents, particularly in semi-developing countries such as Sri Lanka (Schiavi et al., 2022).

Despite the significant economic influence of the construction sector, the country nonetheless has a considerable number of accidents and fatalities. As per Wu et al. (2016), there is a common belief among employers and clients that investing in a safety management system is a cost-effective measure. As a result, they tend to overlook its importance. The importance of safety elements cannot be overstated, particularly in the context of a construction project. However, it is surprising that a significant number of employers are unaware of its role in contributing to the success of organizations. The construction business is widely recognized for its physically demanding and labor-intensive character, which contributes to a high risk of injury. Additionally, there is sometimes a lack of clarity on the duties of each party engaged in a project, which can compromise safety (Tang et al., 2019). The safety precautions are essential for ensuring a more secure and improved working environment on the construction site, and should not be ignored.

## 1.2 Problem Statement

The construction industry is expected to face significant demand due to road development, particularly highways and national road networks. This is likely to make the construction industry one of the most unstable industries worldwide (Li et al., 2018).

Sri Lankan road construction is labor-intensive and hence poses a significant risk to both expert and unskilled workers with varying educational backgrounds (Rameezdeen et al., 2003). The report further indicated that the construction industry constituted around 25% of all labor accidents and exhibited higher rates of fatal accidents compared to other industries. According to Risath, et al., (2016), the data provided by the Labour Department reveals that Table 01 presents the statistics for construction site accidents in Sri Lanka. Each year, the Labor Department's Industrial Safety Division receives a range of 2500 to 3000 recorded events.

**Table 1.1 Construction Site Accident in Sri Lanka**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Fatal Accidents	12	12	16	3	4	8	10	16	19	13	13	12	14	15	19
Non-Fatal Accidents	280	218	61	54	110	130	103	138	123	121	86	45	50	89	113

(Source: Risath, et al., 2016)

Many Sri Lankan construction companies that specialize in road projects have a notable lack of risk awareness and fail to prioritize the health and safety of their employees. Presenting the dangers faced by industrial workers as a normal occurrence is a discouraging reality. 'Safety First' is a popular expression that is commonly shown on several construction sites. However, despite its presence on signboards and posters, it does not necessarily reflect an actual prioritization of safety. Hence, it is unsurprising that the rates of accidents at construction sites show an annual increase. Therefore, this research examines safety-related concerns in road construction from the perspective of construction executives in Sri Lanka.

### **1.3 Aim and Objectives**

#### **1.3.1 Aim of the Research**

This study aims to enhance the safety in road construction in Sri Lanka.

#### **1.3.2 Objectives**

- 1 To review safety issues in road construction in a global context and Sri Lanka.
- 2 To explore the reasons for existing safety issues in the Sri Lankan Road construction industry.
- 3 To identify the factors contributing to existing safety issues in the Sri Lankan Road construction industry.
- 4 To propose solutions to overcome safety issues in the Sri Lankan road construction industry.

### **1.4 Scope and Limitations**

The research specifically examined the active projects, including those undertaken by Sri Lanka's Road Development Authority. However, it did not include ongoing projects in the eastern and northern areas of the country. The road-construction projects were excluded due to the challenges of obtaining and gathering data since they are situated distant from the location where this study work is being conducted. However, most of projects have been temporarily put on hold as a result of the economic crisis in the nation. This is a potential challenge when it comes to data collecting, since a considerable portion of the crew, including those with knowledge in construction, may not be available. Another constraint arises when data collection is necessary, since it may not encompass all workforce groups within the sector. This restriction is attributed to the nature of the study and the low literacy levels among workers involved in road-construction projects.

## **1.5 Chapter Breakdown**

### **Chapter 01 – Research Background**

This chapter establishes the research issue, and explain why the investigation is necessary. The research challenges and theories are also discussed and define essential words and discuss the study's approach's breadth and depth.

### **Chapter 02 – Literature Survey**

This chapter presents the theoretical framework pertinent to the research question and describes the basic concepts utilizing, among other researches.

### **Chapter 03 – Research Methodology**

Chapter 03 describes topics such as goal, methodology, sample selection and participation, data collecting techniques, data analysis equipment, quality standards, and process.

### **Chapter 04 - Data Collection and Analysis**

This chapter summarizes the research study's findings while presenting the specifics of data collecting and analysis.

### **Chapter 05 - Conclusion and Recommendation**

The findings drawn from the studied data and other study fields are included in this chapter.



## **CHAPTER 02 – LITERATURE REVEIWIW**

### **2.1 Chapter Introduction**

The literature review for the analysis of safety issues in road construction in Sri Lanka delves into existing research and scholarly works that address various facets of safety concerns within the construction industry, specifically focusing on road infrastructure projects within the Sri Lankan context. This comprehensive review aims to synthesize and critically analyze pertinent literature, including academic journals, governmental reports, and industry publications, to identify prevailing safety challenges, regulatory frameworks, best practices, and potential solutions. By examining the breadth of available literature, this review sets the foundation for understanding the complexities surrounding safety issues in road construction, providing valuable insights for further research and practical implementations

### **2.2 Construction Industry**

Based on the Central Bank records, the Sri Lankan construction sector had a notable growth of 8.1% and employment in this sector has also increased by 8.4% in 2012 (central bank annual report 2019). The construction industry is widely recognized for its inherent risks and dangers, which may lead to several workplace challenges. The most prevalent ones include the absence of construction safety regulations or guidelines, inadequate integration of high-risk accidents at work sites into the sector's legal framework, a scarcity of suitably qualified, trained, and safety officers, and a dearth of facilities for regular health examinations, as stated in the national occupational health and safety policy report (Pan & Zhang, 2021).

Construction, being the largest industry in the world, plays a crucial part in the progress of every nation. This industry plays a crucial role in directly supporting the livelihoods of numerous individuals. Consequently, the term "construction industry" encompasses a diverse array of activities that hold significance for us in various ways. These activities play a crucial role in safeguarding our financial stability and offering us modern amenities like buildings, roads, waterworks, hydro-power works, irrigation systems, and more (Xiao et al., 2022). The construction sector is characterized by a wide range of participants, techniques, and organizational frameworks. The success of the construction company relies heavily on the contributions of several stakeholders,

such as clients, architects, engineers, consultants, builders, manufacturers, suppliers, and service providers. Each of these individuals or entities plays a crucial part in ensuring positive outcomes. Moreover, the complexity of modern construction projects requires the participation of proficient experts in areas such as design, engineering, management, surveying, and other related fields (Maciej Serda et al., 2013).

### **2.3 Road Construction Industry**

The mobility of citizens is crucial for modern society, with transportation playing a pivotal role in facilitating this. Roads, railroads, rivers, and airports are all forms of transportation infrastructure that have been constructed, and they have significantly enhanced the accessibility of formerly inaccessible areas. The ease with which work and enjoyment may be accomplished through transportation is one of its most significant attributes. People have the option to visit work or study facilities, while firms have the opportunity to establish connections with both competitors and clients. Improved transportation and associated infrastructure will positively impact the well-being of citizens and the economy of a nation in several ways (Bello et al., 2021). This essay examines the favorable economic effects of transportation. These benefits encompass enhanced productivity, increased employment opportunities, and an overall improvement in the quality of life. This study focuses on the transportation industry. The demand for automobiles and gasoline for transportation services contributes to the growth of GDP. In 2016, value-added transportation services accounted for 5.6 percent of the US GDP. The transportation industry acts a crucial role in a country's economy. Expenses encompass many items such as fuel, spare components, lubricants, and vehicles. Acquiring these products enhances the economic benefits of the transportation system (Baduge et al., 2022). An analysis of road investment may be incorporated into the planning process to maximize the benefits of the chosen financial expenditure. An economic evaluation is conducted to assess the potential return on investment and the associated costs. Typically, the road authority is responsible for covering the original investment as well as the annual maintenance costs in most situations. Drivers have the opportunity to reduce expenses when there are enhancements in the road infrastructure (Che Ibrahim et al., 2022). These components

are essential for meeting all the transportation needs of a vehicle and are occasionally known as "total life cycle expenses". Therefore, it is crucial to identify measures that might effectively reduce transportation expenses over an extended time, such as the projected lifespan of the road. The administration of road construction has become increasingly difficult due to the demand for more advanced facilities within shorter timeframes. For a road to be operational, it is essential to have proper drainage, effective utilization of time and space, and a significant emphasis on safety (Kumar et al., 2022).

### **2.3.1 Sri Lankan Road Construction Industry**

The British Governor of the Kandyan kingdom made a strategic decision to govern the nation by implementing a well-connected road network. This network aimed to link the main towns together and also connect them to the Maritime Provinces, which were under their stronger influence. This marked the start of Sri Lanka's road construction history in 1818. In the 1950s, the responsibilities of the public work department (PWD) were constructing and managing the primary road network in the nation. During the mid-1960s, the exclusive responsibility for designing and constructing public buildings and streets rested with the public works department. In 1969, a significant policy shift resulted in the establishment of a Department of Highways. The primary goal of the organization was to build and upkeep the 28,000 km of A, B, C, D, and E class roadways, which were previously under the jurisdiction of the Department of Public Works.

Following that, in 1971, the principal duties of the Highways Department were transferred to the Territorial Civil Engineering Organization (TCEO). From 1970 onwards, the responsibility for overseeing all major bridge construction in the country was shared between the PWD and the highways department. The State Development and Construction Corporation (SD & CC) was founded by the TCEO to effectively oversee the construction of bridges and other civil engineering projects. The Highways Sector had a significant reorganization in 1978 when the TCEO was abolished and its responsibilities were transferred back to the Highways Department. The Road Development Authority (RDA) was established in 1983 as a part of the Ministry of Highways, in accordance with the RDA Act No. 73 of 1981. Following the transition

from the Department of Highways to the RDA in 1986, the RDA's jurisdiction was expanded. In 1986, the responsibility for the construction and maintenance of all classified roads in the country, including A, B, C, D, and E class highways, amounting to about 28,000 km of roads and their associated bridges, was assigned to the RDA. In 1989, the implementation of the 13th amendment to the constitution resulted in the devolution of authority, granting jurisdiction over the C, D, and E class roads, spanning over 17,000 km, and the bridges situated on these routes, to the Provincial Councils.

The RDA has been responsible for the development and maintenance of the National Highway Network, which includes the Main (B class) and Trunk (A class) highways. By the end of 2005, the National Highway Network consisted of the routes that had been officially recognized as National Highways in the preceding years.

Sri Lanka's large and well-maintained road network effectively connects the country's population and important economic areas. Asia boasts the most extensive network due to its higher number of road kilometers per 1000 inhabitants compared to Pakistan and Bangladesh, both of which have densely populated areas. Despite the extensive and well-developed road network in Sri Lanka, there is now a significant constraint on transportation. Pakistan has a road density of 1.69, whereas Bangladesh has a road density of 2.0 and Sri Lanka has a road density of 5.19.

The current road network comprises around 11,700 kilometers of Class A and B national highways. The total length of provincial highways in Class C, D, and E is 15,000 km, while local governments oversee 65,000 km of roads. Additionally, there are 24,000 km of roads under the management of wildlife, irrigation, and other agencies. The National Road Master Plan was published in 2007.

About 50% of the national road network, has been identified as being in a deteriorating state and require upgrades or rehabilitation. The Sri Lankan government has pursued a program during the past two decades aimed at improving the country's existing road infrastructure. In the past decade, there has been a significant increase in traffic volume, resulting in a shortage of resources to meet the growing demand. Studies in this field have demonstrated that extending and refurbishing existing highways to handle growing traffic levels while preserving a substantial level of service is a

complex endeavor that necessitates substantial land acquisition, demolition of structures, and relocation of service utilities.

The Road Development Authority has proposed expressway systems as a viable approach to improve the road network and satisfy the necessary standards. The anticipated expressways and roads include of six key projects: the Colombo – Katunayake Expressway, Southern Expressway, Outer Circular Highway, Central Expressway, Jaffna Expressway, and Extension of Southern Expressway. Although a section of the Central Expressway has been completed, the Southern Expressway and Colombo-Katunayake Expressway, the Southern Expressway Extension, and the Outer Circular Highway, which were mentioned before, have already been completed. The renovations to the Colombo-Jaffna Expressway are anticipated to commence shortly.

Road repair, road upgrading, and highway construction encompass a wide range of jobs. Some of the main civil work construction activities include excavation and site clearing, road formation enhancement, embankment construction, sub-base construction, dense graded aggregate with asphalt concrete overlay, concreting, placing traffic signs, placing road markings, constructing bridges, constructing culverts, and moving utilities. The demand for aggregate and soil used in road construction is now strong. These materials are often sourced from metal quarries and borrow pits, which are generally located far away from construction locations. Contractors involved in road construction possess a share of the quarries and borrow pits, with the remaining resources being provided by privately owned locations.

#### **2.4 Legislations Pertaining to OSH in Road Construction**

Standards and rules on occupational health and safety (OHS) provide technical guidance aimed at reducing workplace hazards. Occupational health and safety concerns can have both long-term and short-term repercussions, as shown in N. Holmes' 1999 study on risk control approaches for small firm construction enterprises. The combination of insufficient enforcement of safety laws and lenient safety standards results in hazardous working conditions. (Watterson, The International Construction Industry Special Issue, January 2007).

Based on common law, ensure the safety and well-being of all their employees is one of employers' major responsibility. Furthermore, all employment contracts must ensure that corporations prioritize the protection of their employees' health and safety. Employers are accountable for both their carelessness and the negligence of their workers, as well as for vicarious liability. In addition, an employer must provide a secure work environment, uphold a reliable work system, provide the essential equipment, and recruit competent personnel to successfully carry out the tasks (Chea and Huijismans, 2018). An employee has the right to leave and pursue legal claims, such as constructive unfair dismissal and personal harm if an employer neglects their responsibilities in these areas (Yamada, 2004). The location where workers were working during the accident is under the direct responsibility of the employer. If the employer fails to meet a legal requirement, they may also be held responsible for any carelessness that contributed to the accident (Nohr, 2009).

Legislation on Occupational Safety, Health, and Welfare (OSH&W) is enacted to safeguard employees from potential damage arising from their anticipated jobs. The main objective of OSH law is to safeguard individuals' lives, physical well-being, and inherent capabilities against any adverse consequences arising from industrial operations or employment. The application of the ILO's OSH 2001, the British Standard's BS18004 of 2008, and the Occupational Health and Safety Assessment Series' OHSAS 18001 of 2007 and OHSAS 18002 of 2008 is anticipated to address the challenges presented by the rapid progress of technology in the OSH&W field. The Sri Lanka Standards Institution has made modifications to OHSAS 18001 of 2007, resulting in the creation of SLS OHSAS 18001 of 2007. The following is a list of Sri Lanka's current primary laws pertaining to occupational safety and health.

- The Workmen's Compensation Ordinance.
- The Factory Ordinance; No.45 of 1942
- Mine and Minerals Act (No.33 of 1992)
- Explosive Act (No.33 of 1969)
- Presidential Directive, PD/498 dated, 01.08.1995
- Chapter XIV in the Penal code

## **2.5 Fatal Accidents in Road Construction Sites**

Based on the study conducted by Ahamed, Nafeel, Rishath, and Dissanayake (2011), it is evident that accidents occur often within the building construction sector in Sri Lanka. Furthermore, safety is considered a matter of utmost importance in this business when compared to other sectors. Accidents are responsible for tragedies such as environmental damage, property devastation, and harm or death to humans. Moreover, accidents give rise to total cost that has the potential to influence the economy by causing any project delays. Studies suggest that the costs associated with post-accident charges, such as delays, are generally far more than the initial investment in establishing and maintaining safety laws.

The main factors contributing to accidents of the construction industry are falls from heights, falling items, collisions with moving objects, entrapment, and exposure to heat, electricity, or dangerous substances. Based on research from the Portuguese Road Institute (2010), the construction of roads is a potentially hazardous task that encompasses many phases and includes various stakeholders. An investigation of accidents data revealed most significant risks were falls and collision with moving items. The majority of incidents occurred in the morning, and viaducts and bridges were the primary locations where accidents took place. Moreover, it has proven that the implementation of a framework was essential to guarantee that contractors effectively collaborated on health and safety measures throughout road construction. Moreover, it underscores the importance of establishing a system that would provide a shared safety framework for all stakeholders in construction projects. The document also delineates the duties and liabilities of both parties and contractors about health and safety. This includes the implementation of government-mandated systems, the establishment of an effective monitoring system, the promotion of a safety-oriented culture within the organization and among contractors, and the integration of these systems with other management functions such as quality assurance and cost-efficiency.

According to data from the International Labour Organization (ILO), the number of fatalities in construction-related workplace accidents exceeds 60,000 annually. Asia and the Pacific account for over 64% of these occurrences, whereas the Americas

account for approximately 17%, Africa for about 10%, and Europe for roughly 9% (ILO, 2015).

According to research from the National Institute for Occupational Safety and Health, workers involved in road and street construction face the risk of sustaining severe or even fatal injuries due to their proximity to incoming traffic, construction vehicles, and equipment. Additionally, it is stated that highway and street construction results in more than 100 worker fatalities and over 20,000 worker injuries per year (Pratt et al., 2001).

Typically, road construction workers perform tasks near operating machinery. According to Pratt et al. (2001), the majority of deaths in highway construction work zones happen when a worker is hit by construction equipment or another vehicle. The document further explains that employees in this industry face the potential danger of being hit by a construction machine component while navigating through the work area. The authors also reveal that a significant portion, specifically half, of the deaths associated with construction equipment occur during the process of reversing. The text also explains that the presence of blind spots, resulting from the usage of construction equipment, contributes to the high level of risk associated with road construction as a profession.

Research conducted by Pegula (2010) found that there was a total of 639 fatal occupational injuries at road-construction sites from 2003 to 2007. Out of the individuals named above, 97 were identified as men. The primary factor leading to fatal occupational injuries at roadside construction sites is automobile accidents involving individuals or mobile equipment. The data also indicates that a significant portion of the fatal occupational injuries, namely 305 out of 639, that caused by strikes involving autos or other mobile equipment. Out of all the deaths, a total of 133 workers, which accounts for 33% of the total, were involved in construction activities. Out of the total, 37 individuals, which accounts for 12% of the group, were employed in the role of highway maintenance workers. Crossing guards, including flaggers, were responsible for 27 deaths (9%), while first-line construction managers and supervisors were responsible for 27 deaths (9%). The report also indicated that 10% of the fatalities



were from incidents where workers were struck by a reversing dump truck. The employee was struck by an automobile without a backup alarm on twenty-five separate times. Additionally, there have been ten fatalities caused by drunk driving within the specified period.

## **2.6 Safety Issues in Various Road Construction Activities**

Every road construction activity has significant risks for the workers. The safety concerns in various road construction-related operations are covered in the following areas. In this section, an in-depth exploration of existing scholarly works, safety regulations, and accident analyses related to various construction activities of road construction are undertaken. This comprehensive review seeks to provide a foundational understanding of the prevalent safety issues in the global construction landscape, offering insights into best practices, challenges, and potential solutions.

### **2.6.1 Safety Issues Associated with Quarries and Barrow Pit Operations**

Employees working in borrow pits and quarries face significant hazards. The term "borrow pit" refers to the location where natural granular materials such as soil, gravel, sand, or weathered rock are removed for road construction purposes. A quarry provides rock materials that usually excavate by blasting, to provide rock aggregate for road construction.

Several deficiencies and improper procedures have been discovered during Safety checkups of several quarries in Newfoundland. If early preventative actions are not implemented, these deficiencies might lead to health issues in both the short and long term. Various deficiencies have been observed, including improper removal and storage of overburden from the quarry edge, incorrect face and bench heights of equipment, a lack of dust suppression systems, improper implementation of hearing conservation programs, and an insufficient provision of HEPA filtration systems ([www.ohs.gs.gov.nl.ca](http://www.ohs.gs.gov.nl.ca)).

Working in quarries is considered one of the most hazardous occupations. Employees in this industry have a much greater risk of work-related fatalities compared to those in the manufacturing and construction sectors. According to a report by OSHA Europa, the risk of dying at work is 13 times higher for quarry workers than for those in the

manufacturing sector, and they are twice as likely to die in a work-related accident compared to those in the construction industry. The main hazards in the quarries are usage of large earthmoving equipment and trucks, handling explosives and big loads, constant exposure to airborne dust, and working in extreme environmental conditions. In the quarrying industry, the majority of deaths are attributed to maintenance, moving machineries, and falls.

Moreover, these workers face a multitude of dangers, such as the regular requirement of heavy lifting, exposure to vibrations and noise, as well as potential contact with hazardous substances including gas, oil, welding fumes and lubricants. Moreover, they are engaged in doing arduous activities, often dealing with pressurized fluids and operating gear that is functioning. The risks and hazards commonly associated with quarries encompass various aspects. These include working on faces and post-operation clean-up, potential dangers related to vehicle operations, accidents involving machinery. Additionally, there is a risk of being struck by falling objects or machinery, as well as hazards associated with vibration and manual handling. Other concerns include exposure to dust and noise generated by stone crushers, heavy vehicles and blasting activities. Lastly, there is the potential for exposure to extreme weather conditions.

Workers responsible for the upkeep of roads and quarry surfaces encounter a range of hazards. These include the potential for trees and other debris to slide onto individuals and machinery from the tailings area, exposure to noise and dust, the risk of falling materials such as boulders, the possibility of slips and falls from elevated positions, and the danger of being entangled with moving gear. When operating rock drills, workers are exposed to many risks including falls from the machine, tripping over the drill rod, being stuck in its mechanism, and potential harm from the drill's noise and dust. Workers who repair the wheel loaders, excavators, and caterpillars face potential hazards such as falls, entrapment, and crushing incidents resulting from incorrect lifting methods, as well as unintended vehicle movement. The stone crushers include several risks, including dust-related hazards, noise, electrical dangers arising from inadequately insulated electrical parts, and ergonomic issues such as working in uncomfortable positions. Due to the regular performance of maintenance on conveyor

belts while they are still in operation, individuals undertaking this task face considerable danger. Conveyor belt maintenance and repair work has potential hazards, including the danger of injury from moving parts, falls from elevated areas, and exposure to extreme sound and particulate matters ([www.osha.europa.eu](http://www.osha.europa.eu)).

### **2.6.2 Excavation Safety Issues**

Road construction projects always include the execution of high-risk jobs, such as deep excavations. These tasks are especially common on construction sites where bridges and culverts are being built. Workers engaged in trench digging or excavation face a potential fatality risk if it is not protected and experience a failure of the side walls. Excavations that reach a depth of five feet or more are subject to OSHA regulations on the use of protective measures. These measures include techniques like benching, sloping, shoring using planking and hydraulic jacks, or utilizing trench boxes for shielding. The report further explains that several elements, such as soil type, soil water content, environmental conditions, proximity to backfilled excavations, the weight of heavy equipment or tools, and vibration from machinery, have an impact on soil stability and the potential hazards faced by workers.

### **2.6.3 Asphalt Work Safety Issues**

Working with asphalt poses health dangers. Asphalt is a substance with a cement-like consistency that is produced during the distillation process of crude oil refining. Research has revealed that fumes created at a high temperature are more likely to produce polycyclic aromatic hydrocarbons (PAHC) which are considered a carcinogenic substance. Research on worker exposure to asphalt fumes has consistently observed bothersome symptoms affecting the mucous membranes of the upper respiratory tract, such as throat, nasal, and eye irritation. Research has further demonstrated that certain workers involved in asphalt paving activities have experienced pulmonary function abnormalities and reported symptoms related to the lower respiratory tract. According to the Hazard evaluation in 2000, there have been reports of bronchitis among asphalt workers and highway maintenance personnel. This might perhaps be linked to irritation in the lower respiratory tract.

#### **2.6.4 Safety Issues Associated with Bridge Construction**

Bridges play a crucial role in road development since they are essential for providing people with comfortable travel. They successfully navigate across various difficulties such as mountains, gorges, rivers, and so on. Bridge construction safety faces a multitude of hazards and challenges due to its structure nature and the various environmental conditions involved.

Based on the research conducted by Zhi Shan and colleagues, several risk variables were identified that caused accidents in bridge construction. Human factors have a significant role in several operational challenges, including noncompliance, insufficient technical competence, poor managerial competency, fatigue, weak safety awareness, and operational errors.

There are several factors related to equipment that might have a negative impact. These include inadequate maintenance of equipment, defects in equipment and material quality, improper ways of material utilization, equipment failures, inappropriate equipment selection, and improper material storage.

**Management Factors** – The ineffective execution of management systems, insufficient safety training, unreasonable construction plan, loopholes in laws and regulations, lack of supervision and management, and inadequate safety inspection.

**Environmental Factors** - Impact the project include unfavorable geological and hydrological characteristics, complex traffic circumstances around the site, complex subterranean utilities, severe weather conditions, an unfavorable construction environment, and the risk of natural catastrophes.

The Japan International Cooperation Agency (JICA) issued a road and bridge construction safety control handbook in 2019 to protect personnel from accidents. This document outlines general safety procedures for the building of bridge projects in Southeast Asian nations. Before starting the work shift, it is important to clean the site for 5-10 minutes. It is also crucial to take precautions against heat stress by staying hydrated, taking breaks to rest, and avoiding working directly under sunlight. Additionally, it is necessary to have a medical practitioner available at remote work locations, provide first aid facilities, and conduct regular health checkups. Personal

protective equipment such as helmets, shoes, reflective jackets, safety belts, gloves, goggles, and masks should also be provided.

### **2.6.5 Occupational Ergonomics in Road Construction**

Ergonomics is another important factor that must be taken into account in the road-construction sector. Choi et al. (2007) have observed that workers in highway construction are at substantial risk of musculoskeletal injuries due to nature of their profession. Many mishaps are often caused due to adopting uncomfortable postures and engaging in physical material handling. Construction labor requires frequent transitions between tasks, encompassing activities performed both above the shoulder and below the knee, as well as everything in between. Furthermore, the work surface experienced by employees undergoes frequent changes throughout the day, hence intensifying ergonomic issues. Upon further research, it has been determined that the predominant types of injuries were sprains and strains. Additionally, strains, sprains and back injuries were observed in descending order of severity. The research findings indicate that the primary cause of damage was overexertion, followed by motion/position and slip/trip, in that specific sequence. Additional reported sources include tools and equipment, sharp edges, being struck by objects, and exposure to chemicals. Another discovery made throughout the survey was that most contractors did not have customized ergonomic methods for their particular work areas.

### **2.6.6 Poor Safety Climate and Lack of PPE**

The construction business has a lengthy track record of being negatively perceived in terms of worker safety and health. Before attempting to increase performance, it is crucial to promote an occupational safety culture (Mohd Saidin et al., 2007). Consequently, there is a pressing need for a substantial transformation in the way safety is seen and approached on construction sites. Developing a comprehensive knowledge of behavior provides valuable insights into areas that have potential for improvement, such as enhancing personal safety, optimizing planning processes, or increasing work efficiency. A viable resolution to this underlying problem is imperative.

The term "safe climate" was introduced to describe how employees view the significance of prioritizing safety concerns. The supply of personal protective equipment (PPE) by professionals; Based on expert opinions, the utilization of protective equipment (PPE) is believed to contribute to a reduction in construction accidents. However, research indicates that this notion may not be accurate, since a significant number of incidents have happened despite the usage of safety gears. According to several studies, it is widely believed that the health and safety concerns in highway construction may be attributed to inadequate choice and usage of safety gears (Xiao et al., 2022). Hence, this result substantiates the necessity of worker participation in the selection of safety gears. According to several experts, the requirement for workers to wear personal protective equipment (PPE) in non-essential situations is often perceived as trivial by workers, leading them to not take it seriously, even in situations when catastrophic injuries might occur.

Additionally, depending on personal protective equipment (PPE) might create a misleading feeling of safety among workers, leading to decreased vigilance about their environment and behavior. transit accidents are more likely to occur with moving vehicles, particularly on the roadside, due to the need for workers to interact with public transit. While drivers are primarily responsible for this tragedy, construction teams can take measures to mitigate the risk (Boje et al., 2020). During the implementation stage, it is advisable for roadside construction sites to install a notice board to alert drivers about the oncoming road traffic. In addition, it is essential to shut roads before commencing work at construction sites, and workers must don high-visibility clothes. An effective strategy to mitigate workplace accidents is the implementation of a buffer zone consisting of cones and barriers (Che Ibrahim et al., 2022).

#### **2.6.7 Poor Safety Behaviors and Practices**

Meaning of the safety behavior is actions that promote safety such as providing adequate training and ensure safety regulations compliances (Mahmood et al., 2010). They also explain the essential tasks that employees need to carry out in line with safety regulations to reduce injuries at the work.

As stated by Johnson (2003), the implementation of safety behavior plays a crucial role in reducing workplace injury rates and exerting an indirect influence on the occurrence of accidents or injuries.

In the study conducted by Zin and Ismail (2012) titled "Employers' Behavioral Safety Compliance Factors towards Occupational Safety and Health Improvement in the Construction Industry," Abang Abdullah et al. (2005) referenced Fredrick's (1982) ABC model. This model outlines the impact of activators and consequences on behavior. Promoting safety compliance proactively necessitates the use of measures to enforce safety behavior variables. The text also states that extensive research on workplace safety consistently supports the notion that, in most industries, incidents and accident rates are mostly attributed to employees not adhering to safety laws.

As per research done by Jaselsky et al. (1996), as cited by Zin and Ismail (2012), senior management must demonstrate commitment to achieve the safety goals of a company. Further study has revealed that the main factor contributing to the majority of construction-related mishaps is the lack of adherence to safety requirements in most industries.

According to Zohar (2002), as stated in Zin and Ismail (2012), the implementation of better communication channels has resulted in a decrease in micro accidents and a rise in the utilization of personal protective equipment (PPE).

As per Titas (2013), unsafe conduct at work may be attributed to two main factors: insufficient awareness regarding safety measures and a pessimistic attitude towards them. If staff were provided with more knowledge or training on safe conduct, it is hypothesized that the occurrence of accidents may potentially be reduced. The paper identifies employees' inability to assess operational risks, insufficient monitoring and control measures, and poor work organization as the primary factors contributing to catastrophic accidents on construction sites in European nations. The statement also asserts that there are numerous work-related infractions of occupational, health, and safety rules. Employee ignorance and a lack of training and expertise have been identified as key factors directly associated with accidents in the construction sector.

## **2.7 Factors Contributing to Safety Issues**

A primary factor contributing to health and safety concerns in developing countries is the absence of comprehensive guidelines and legislation for health and safety. Hence, the government must establish comprehensive guidelines and laws about health and safety protocols. It is imperative to furnish safety gear to all colleagues and administer pre-safety training before commencing the construction endeavor. Moreover, this law ought to incorporate sanctions for failure to adhere to regulations, to mitigate risks in highway construction (Nedelikovic et al., 2021). While all construction labor has inherent risks, some projects, such as highway construction, entail greater hazards and unique obstacles. The supervisory authority should prioritize the safety of construction workers. Gaining insight into the hazards faced by employees is essential in the initial phases of mitigating health and safety issues. The citation is from Torriani et al. (2023). Nevertheless, it has been previously stated that the institution guides the government about activities outlined in the National Professional Institute Safety and Health Act, No. 38 of 2009 (b) in Sri Lanka. To prevent accidents and injuries in the workplace, it is necessary to carry out and endorse academic programs, surveys, and research in the field of occupational safety and health (Mohtasham Moein et al., 2023).

The construction business has a higher incidence of occupational injury compared to all other key industries combined (Lehtola et al., 2008). Construction, unlike manufacturing and other economic sectors, relies on a transient workforce (Dubois and Gadde, 2002; Kadefors, 1995). Project personnel with many backgrounds and cultures must collaborate in a dynamic work setting. Construction poses inherent risks owing to external factors, working at elevated levels, complex on-site machinery and equipment operations, and the attitudes and actions of workers towards safety (Choudhry et al., 2007). According to data provided by the International Labor Organization, (ILO, 2016, n.d.) (Hämäläinen, 2009), construction sites account for more than 30% of all fatal occupational injuries, resulting in the yearly murder of at least 108,000 workers. Statistics from many industrialized countries indicate that employees in the construction sector have a significantly higher risk of fatality in workplace incidents compared to those in other industries, with a three to fourfold increase in likelihood. Construction in underdeveloped nations has a significantly



higher risk, ranging from three to six times greater than in other regions. Work-related accidents can result from hazardous conditions that have detrimental effects on employees' health and physical well-being. Additionally, accidents can occur when individuals or property are directly hurt physically (Denton, Zeytinoglu, & Davies, 2002). The expenses associated with accidents, both direct and indirect, can be significant. Based on estimates from BRT (1995) and Anderson (1997), the costs of accidents represented 6.5% of the overall value of finished work in the USA and around 8.5% of the tender value in the UK. A study conducted in the UK found that the advantages of accident prevention outweighed the expenses by a ratio of almost three to one when considering the entire costs and total benefits of accident prevention (Ikpe, Hammon, & Oloke, 2012). Consequently, irrespective of their scale, contractors earn \$3.00 for every £1.00 they invest in accident prevention. (Ikpe et al., 2012). Contractors possess the ability to comprehend the financial impact of accidents, which can be measured and connected to their sales statement, balance sheet, and project financial records (Tang et al. 2004; Booth and Panopoulos 2005).

The Mitropoulos model, proposed by Mitropoulos et al. in 2005, asserts that two actions must be taken to prevent accidents: (a) implementing accurate production planning to minimize job unpredictability, and (b) implementing error management strategies to improve workers' capacity to identify, rectify, and mitigate mistakes. The primary factors identified as contributing to accidents in Uganda's construction industry were inadequate supervision, employment of inexperienced workers, and utilization of incorrect construction methods (Lubega et al., 2000). The study concluded that various factors, including chemical impairment, mechanical failure of construction machinery/equipment, recruitment of incompetent personnel, lack of enforcement of safety regulations, physical and emotional stress, lack of professionalism, disregard for safety among individuals involved in construction projects, and lack of knowledge of safety regulations, also played a role.

Research conducted in Malaysia by Hamid et al. (2008) identified several primary causes of accidents on construction sites. These include worker negligence, disregard for safety procedures, working at heights, operating machinery without safety devices, poor site management, challenging working conditions, worker incompetence, failure

to use personal protective equipment, and a poor attitude toward safety among the workforce.

Increased traffic loads, especially in metropolitan areas, are nearing the design limits of many transportation systems. Persistent congestion and substantial traffic. Any diurnal work on these thoroughfares that requires upkeep, refurbishment, or reparation hinders vehicular flow and augments congestion and delays. Hence, it is prudent to schedule construction and maintenance work during the nighttime hours when traffic volume is low (Garber & Hoel, 2019). According to Lee and Thomas (2007). He stated that nighttime construction not only reduces the impact of construction operations on the public's capacity to commute but also provides further advantages. The advantages encompass a decrease in interruptions and a prolongation of the duration of construction operations. Nevertheless, the nocturnal construction also has drawbacks that are absent during daylight hours. Nighttime construction operations pose a substantial risk to both vehicles and construction workers due to reduced visibility in the dark (Uehli, Mehta, Miedinger, Hug, Schindler, Holsboer-Trachsler, & Künzli, 2014). Moreover, research suggests that a higher percentage of drivers during nighttime hours are impaired by substances such as drugs or alcohol, fatigue, or vision impairments associated with aging. In addition, the presence of lighting and external factors such as individuals might create a hazardous work environment for night workers (Lerman, Eskin, Flower, George, Gerson, Hartenbaum, & Moore-Ede, 2012). The research conducted by traffic engineering specialists (Wang et al., 1996; Ha and Nemeth, 1995) has placed significant emphasis on ensuring safety in highway construction zones. Although research has shown that the occurrence of accidents in work zones is greater than in highway sections without work zones, there has been no comprehensive investigation of the safety concerns associated with nighttime highway construction and maintenance activities (Pal and Sinha, 1996). As nighttime construction becomes increasingly common practice in projects, data collection is become easy enabling this type of research (Tilt, Braun, & He, 2009).

Construction at night is as straightforward as construction during the day, as sufficient lighting enhances visibility (Abd Elrahman and Perry, 1994). Based on research done by Hinze and Carlisle (1990), it was widely acknowledged by both state transportation

authorities and contractors that adequate lighting required ensuring the safety during night works. The guidelines for illumination for nighttime highway construction and maintenance were established by Ellis and Herbsman in 1996. Weather circumstances, such as wetness, fog, or subfreezing temperatures, can also have an impact on accidents. When an individual is wearing high-visibility safety gear that is in proper working condition, it might have an influence on their visibility within a work setting. An analysis of the literature reveals that several elements, including weather conditions, illumination, worker habits regarding safety gear usage, and the condition of vehicle operators, all have a role in the occurrence of nighttime accidents (Wears, Hollnagel, & Braithwaite, (Eds.). 2015). According to the research findings, a majority of respondents (64%) attribute accidents in construction zones to vehicle operator impairment, while a smaller percentage (43%) feel that poor illumination is the cause. The weather and employees' lack of safety vest usage seem to be very insignificant issues. Some respondents asserted some accidents have occurred even workers used the reflective jackets, indicating a strong belief in the effectiveness of these devices.

As per Barker and Ingram (2011), the proficiency of the workforce has a direct impact on the performance of a firm relative to its competitors. The categorization of employee capability may be achieved by utilizing both general and technical skill categories. As stated by Grrugulis (2007), technical skills are job-specific, whereas general talents can be used in other professions. He proceeded to comment that the overall productivity and employability of workers in the construction sector are influenced by both of these abilities. It is crucial to strike a practical equilibrium between technical and general skill development activities in the workplace to enhance employee competency. Both formal and informal procedures might be employed to create the same outcome (Nilsson, 2010). The employees' performance significantly influences the success of the construction firm. Consequently, in order to effectively achieve their objectives, firms require a workforce that possesses exceptional qualifications (Barker and Ingram 2011). In order for a construction company to achieve long-term success and sustainability, it is essential to prioritize research, invest in workplace training for workers, and focus on skill development and improvement. The construction employees have many challenges in terms of their knowledge and

abilities to effectively handle the increasing complexity of construction projects (Marshall and Tucker, 1993).

## **2.8 Strategies Use to Improve Safety in Road Construction**

The lack of competent health officers is a primary safety concern during the construction of new infrastructure. This implies a lack of individuals with the technical expertise to provide coaching to employees or offer practical safety standards. Regrettably, safety officials are not available to respond to emergencies. Therefore, the construction business must have competent HSE authorities to enhance its safety standards. Contemporary technology is utilized to optimize construction methods, resulting in streamlined processes and reduced timeframes. On the other hand, this has had a positive impact on job safety by reducing the danger to the crew members. The utilization of advanced gear and technology in bridge construction has effectively mitigated the risks involved with handling enormous, heavy concrete beams.

Robotic Safety Cones (RSB) and movable rumble strips exemplify the utilization of advanced technology in road construction to mitigate accidents by redirecting cars and machines. Wang et al. (2023) suggest that several studies have proposed the utilization of movable rumble strips as a means to enhance safety at highway construction sites. Rumble bars function as a means to notify cars of the existing speed limit sign and also act as a cautionary measure. The Robotic Safety Cone (RSC) offers practical benefits such as enhanced mobility for maintenance and construction tasks. This device functioning with a motor which provides necessary power for movement (Sadrizadeh et al., 2021). The gadget is equipped with an application that can effectively reposition the cone while mobile activities are being carried out, hence reducing the probability of a worker being entangled in traffic. According to Asadi et al. (2018), the presence of employees near moving traffic at the workplace decreases the probability of severe accidents. RSC's development and research aim to improve the affordability of safety cones while also boosting the design of cone-shaped roads.

## 2.9 Literature Survey Findings

The results of the literature review that pertain to safety concerns, the causes of those concerns, their contributory elements, and possible remedies fall into the following categories:

**Table 2.1 Safety Issues in Construction Industry**

Safety Issues in Construction Industry	
Not report hazards	Not wearing PPE
Lack of knowledge and awareness on safety issues	Lack of safety information
Lack of skill	Poor organization of work
Employee's inability to assess operational risks	Poor Housekeeping
Horseplay	Unacceptable work practices
Lack of proper/adequate safety facilities and devices	Taking shortcuts
Ignore safety rules	Heavy lifting
Not following safety procedures	Work in awkward positions
Defective tools	Exposure to extreme weather conditions
Missing guards	Unsafe lifting devices and practices
Poor working conditions	Improper insulation of electrical components
Use of wrong tool	Maintenance while running machineries

**Table 2.2 Reasons for Exist Safety Issue in Construction**

Reasons for Exist Safety Issues in Construction
Poor allocation for the personal protective equipment.
Difficulties in getting experienced workers due to low salaries
Lack of facilities to train the workers
Lack of adequate knowledge and skills
Ignorance by the site Engineer and other technical staff
Lack of consideration by the top management
Lack of consideration by the client and Engineer
Lack of site co-ordination
No proper safety policy for the organization

**Table 2.3 Factors Contribute for Safety Issues in Construction**

Factors Contribute for Safety Issues in Construction
Hiring of incompetent personnel
The lack and absence of qualified safety officers
Inadequate training
Use of incorrect construction techniques
Inadequate supervision
Attitudes and behaviors toward safety
Vehicle operator impairment
Lack of health and safety rules and regulations
Chemical impairment
Lack of regard for safety by those involved in construction projects
Poor site management
Lack of vibrancy in professionalism
Lack of knowledge of safety regulations
Physical and emotional stress
Lack of enforcement of safety regulations
Mechanical failure of construction machinery/equipment
Night time work

**Table 2.4 Suggestions to Overcome Safety Issues in Construction**

Suggestions to Overcome Safety Issues in Construction
Provide pre-safety training before starting the construction project
Undertaking and assisting with inspections and academic programs, research and surveys in OSH field by the government
Penalties for non-adherence to reduce health and safety risks
Develop adequate rules and regulations
Use of advance technology

## CHAPTER 03 – RESEARCH METHODOLOGY

### 3.1 Chapter Introduction

This chapter provides the reader with more information about the procedures followed during the investigation, which enhances their ability to assess the study's credibility. In this section, the research strategy, data collection methods, and statistical analyses will be presented as part of the explanation of the methodology used in this study. The demographics and sampling strategy of the study, its data sources, and any ethical issues that surfaced during the investigation will all be covered in this chapter. Readers would certainly have faith in the validity of this research if the approaches used to perform it were transparent.

### 3.2 Research Approach

Research approaches are divided mainly into three categories, which include: (a) quantitative, (b) qualitative, and (c) mixed method approaches. (McCusker & Gunaydin, 2015). Each single approach has its advantages and disadvantages.

According to the definition, quantitative research is a method of gathering numerical data that enables researchers to use mathematical, statistical, or other computational tools to analyze and interpret the data acquired (Muijs, 2010). The ability to cope with bigger sample sizes within comparatively shorter periods for data collecting is one benefit of the quantitative research technique (Rahman, 2017; McCusker & Gunaydin, 2015). According to the authors and others, there are certain drawbacks to these procedures since they only provide superficial glimpses into a phenomenon and ignore the experience of test subjects and testers. Using a qualitative research technique, non-numerical data is gathered and analyzed (Pathak, Jena & Kalra, 2013). To comprehend human experience on several research problems, qualitative research methodologies are now used in a variety of study domains. Focus group talks, interviews, surveys, and documenting observations on what a researcher has observed or heard were the most popular methods of qualitative research (Hall, & Rist, 1999). The key benefits of qualitative research include the ability to capture emotions and impressions, prompting deeper knowledge into creating, and comprehending, while the main drawbacks are

the small sample size and time-consuming nature (Rahman, 2017; McCusker & Gunaydin, 2015).

Positivism maintains that empirical observation and objective and quantifiable techniques of investigating and evaluating things are the only ways to get knowledge. It highlights the need to use rigorous scientific procedures to test ideas and reach conclusions (Plano Clark & Ivankova, 2018). Data on safety conditions Sri Lankan road construction will be collected and analyzed using a positivist methodology (Sodhi et al., 2012). This technique will boost the results' dependability and validity by ensuring that the data provided is objective, quantifiable, and based on facts. This method will also allow the research to give useful insights into the elements contributing to road safety difficulties during construction and suggestions for correcting these issues (Leech, 2015).

Quantitative researchers collect numerical data and use statistical methods to investigate and characterize the correlations between variables (Plano Clark & Ivankova, 2018). When it is necessary to test certain hypotheses or ideas, estimate the frequency of specific occurrences, or identify cause-and-effect relationships, quantitative research is often favored over qualitative and mixed-methods techniques, which involve in-depth evaluations of what people think (Plano Clark & Ivankova, 2018). Quantitative research is distinguished by large samples, strict methodology, and the quest for generalizability and repeatability (Sodhi et al., 2012). While qualitative and mixed-methods research offer advantages, quantitative research provides a thorough and accurate procedure allowing researchers to reach clear conclusions about the subject.

Researchers that use the "Mixed method" research technique gather and evaluate both quantitative and qualitative data (Schoonenboom & Johnson, 2017). The use of mixed techniques is appropriate for study designs when the research issue cannot be addressed by quantitative or qualitative approaches alone. The prior section has already covered both the quantitative and qualitative aspects of mixed techniques' benefits and drawbacks.



This study's quantitative survey technique is a deductive research methodology since its major goal is to evaluate hypotheses and ideas by collecting and analyzing real-world data. This research aims to determine whether worker safety concerns exist during road construction in Sri Lanka and, if so, what those difficulties are. This approach will be able to evaluate the prevalence of these concerns and analyze the correlations between various factors by using a standardized questionnaire to gather data from a large sample of individuals.

### **3.3 Research Strategy**

"Research strategies" refer to the general approaches employed throughout the research. Experiments, case studies, ethnographies, and surveys are all common ways of scientific study. A survey is a common instrument for acquiring data from large groups of people in the area of research. Surveys may reveal people's attitudes, views, and actions since, unlike research, the independent variable is unchanged (Sodhi et al., 2012). Case studies and ethnography give valuable data at the expense of time and the danger of underrepresenting society. A survey is the most effective approach to collecting hard data that can be readily evaluated and compared across groups or periods (Leech, 2015). Moreover, surveys are productive and cost-effective since they may be sent to a vast and varied audience through the Internet, by phone, or in person. Finally, surveys are an excellent research instrument for swiftly and inexpensively gathering information on various issues.

### **3.4 Research Techniques**

#### **3.4.1 Sampling**

Convenience sampling has been used to data collection due to its ease of use and practicality. Convenience sampling is choosing research subjects that are easily reached and willing to participate (Green et al., 2017). Employees from several road construction sites were recruited for the research. Convenience sampling has been used to data collection various persons increasing external validity of the study (Gupta et al., 2020). Since a convenience sample was used, the results may not apply to all road construction business employees in Sri Lanka

### **3.4.2 Data Collection**

The literature review is considered to be the driving force behind the conceptual framework for doing quantitative or qualitative research (Taylor, et al., 1992). A comprehensive examination of the existing literature was conducted to gather information on safety issues associated with construction activities. Safety concerns of global and Sri Lankan road construction sectors were obtained from a comprehensive collection of published journals, papers, books, and electronic media.

A Likert scale questionnaire was used with a 5-level scale from "strongly disagree" to "strongly agree" to gather data for this research. A questionnaire was designed to assess better the nature and fundamental reasons of safety concerns in Sri Lankan road construction. Before the questionnaire was made public, it was subjected to a battery of tests to confirm its correctness and reliability. The survey was piloted by a representative sample of employees whose answers were used to fine-tune the questionnaire (Lai & Hitchcock, 2015). The completed survey was sent to respondents at their supplied email addresses. To ensure a high response rate, participants were reminded frequently while remaining anonymous (Starovoytova, 2018). Implementing an electronic survey will enable more efficient and thorough data collection, more exact data recording, and simple data retrieval and analysis. Using a pre-designed questionnaire and computerized data collecting will improve the study's validity and reliability (Helkkula et al., 2012). This research followed two steps for data collection as mentioned below.

#### **Step 1 – Preliminary Survey**

A questionnaire for gathering data was created based on the findings of the literature and my fourteen years of experience working as an HSE executive in the road construction sector. Preliminary survey was created using the literature findings to investigate safety concerns, factors that influence safety, and solutions to address safety concerns in Sri Lankan road construction projects. The draft survey was given to four experts who are currently working in the industry in order to get their opinions and suggestions on how to improve and expand it to better fit the needs of the Sri Lankan road construction sector.

## **Step 2 – Questionnaire Survey**

The final questionnaire included general information about the respondents and years of experience, the reason for existing safety issues, contributing factors, and a potential solution that suits the Sri Lanka road construction sector was distributed through email and WhatsApp groups among construction executives and health and safety executives who are being employed in road construction projects. 45 personnel responded and returned the filled questionnaires. The results of the literature review were carefully considered when creating the questionnaire. As a result, the information in Table 03 was utilized to determine the causes of the current safety issues in Sri Lankan road construction. After analyzing the contents and as per HSE expertise insight 8 reasons out of 9 identified by the literature survey were tested in the context of Sri Lanka Road construction. Those reasons include,

1. Poor allocation for the personal protective equipment.
2. Inexperienced workers due to low wages.
3. Inadequate knowledge and skills
4. Site Engineer and supervisory staff ignore site safety.
5. Lack of consideration by the top management.
6. Lack of consideration by the client and Engineer.
7. Lack of site coordination.
8. No proper safety policy available for the organization.

Likewise, the information in Table 04 was utilized to analyze the components influencing the safety concerns that are currently present in Sri Lankan road construction. After analyzing the contents and as per HSE expertise insight 8 factors out of 17 identified by the literature survey were tested in the context of Sri Lanka Road construction. Those reasons include,

1. Lack of health and safety rules and regulations
2. Attitudes and behaviors toward safety
3. Inadequate training
4. Poor site management
5. Night time work

6. Use of incorrect construction techniques
7. Lack of enforcement of safety regulations
8. Hiring of incompetent personnel

The information in Table 05 was utilized to provide recommendations for how to address safety concerns with road construction in Sri Lanka. After analyzing the contents and as per 04 HSE executives' insight 5 suggestions identified by the literature survey and 3 suggestions proposed by the experts were tested in the context of Sri Lanka Road construction. Those reasons include,

1. Allocate funding for safety establishment
2. Providing incentives for companies that prioritize safety in their road construction projects
3. Provide pre-safety training before starting the construction project
4. Increasing the number of safety inspections by authorities
5. Undertaking and assisting with inspections and academic programs by the government
6. Penalties for non-adherence to reduce health and safety risks
7. Develop adequate rules and regulation
8. Use of advance technology

### **3.5 Data Analysis**

To effectively evaluate most important elements for this study the "Relative Importance Index" (RII) was used. Moreover, this analytical approach employs statistical calculations to analyze the results of the questionnaire, which are subsequently transformed into factors that have an impact. RII utilizes a ranking algorithm to determine the most significant criterion based on the weight assigned to the scores given by respondents upon completing the questionnaire. The RII approach is employed to ascertain the key elements that exert the most significant impact on Sri Lanka's road-construction industry. The topic and research title are established at the beginning of the study, supported by a comprehensive review of the existing literature. Libraries are organized based on the subject matter of the written material. In this situation, the pertinent libraries would be those containing articles on the utilization of

RII as statistical analytical tool and topics related with construction sector. The data obtained was analyzed using RII and Microsoft Excel 2010 was utilized to do the necessary statistical calculations. The influencing elements of the research were determined by the utilization of the RII method and the subsequent equation: The equation RII is equivalent to the sum of the product of W, A, and N. The Relative Importance Index is commonly referred to as RII. There are five distinct weights denoted by the symbol W. A represents the highest weight observed in this investigation, with a maximum value of five. N represents the overall count of individuals who have responded. The RII is ranging from the value 0 to 1 and the component of the research that will hold the utmost significance is the one that has the highest RII score.

### **3.5.1 Reliability / Validity**

The data collected for this study will be carefully examined to verify its precision and credibility. Given that the questionnaire questions have been tested and piloted beforehand, they will be clear and easy to understand for the intended respondents (Brownscombe et al., 2019). The questionnaire's internal consistency, which measures how effectively separate items evaluate the same concept, will be assessed using Cronbach's alpha. To proceed with this research, Cronbach's alpha must be at a minimum of 0.69. To assess the validity of the question statements, it is necessary to establish a decision rule. The decision process for identifying components that make a substantial contribution was devised by classifying the RII figure into two categories: "accept" and "reject." Individuals were considered to have made a noteworthy contribution only if their RII scores were within the range of very significant to extremely significant, as per the decision-making criteria.

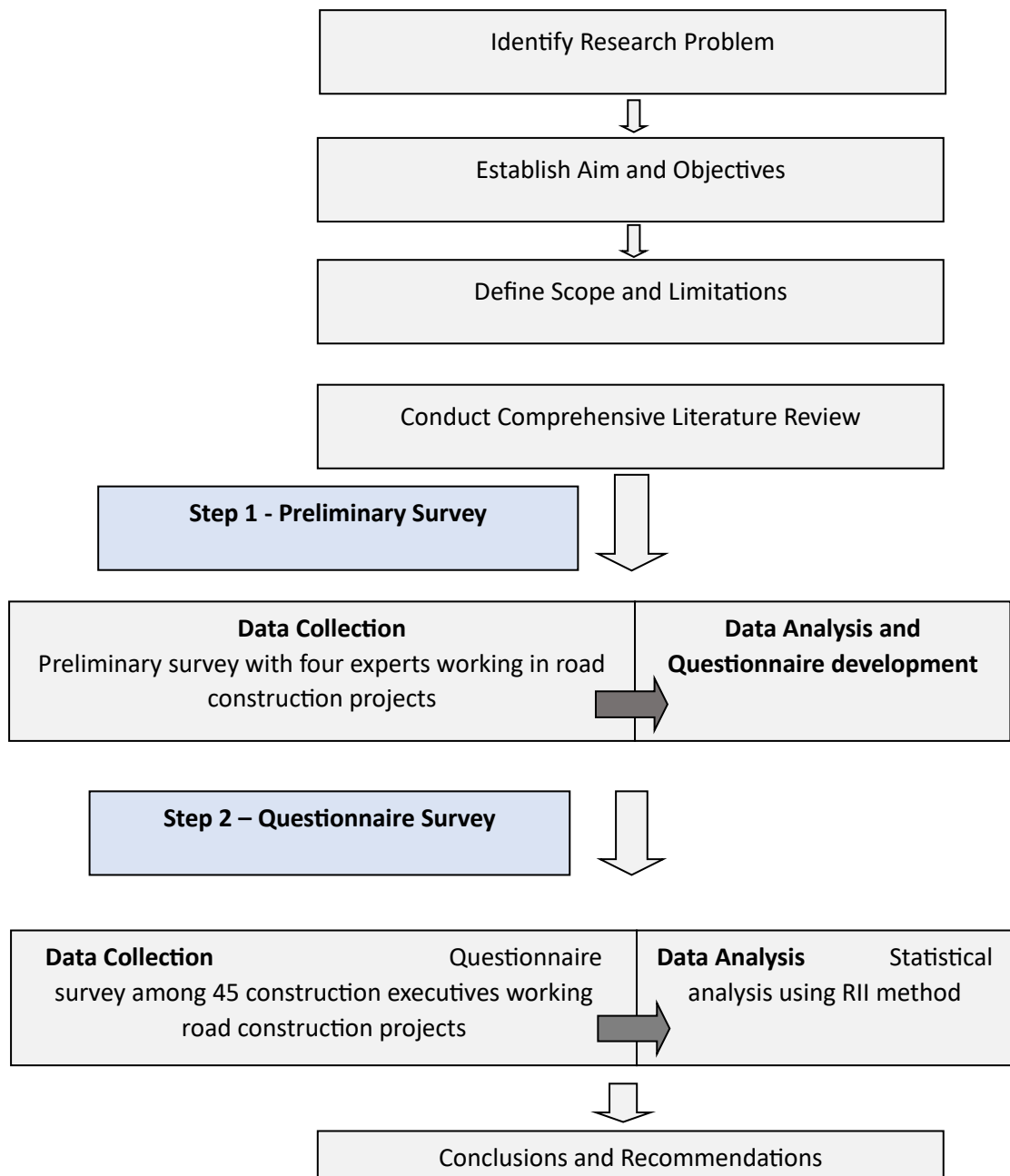
### **3.6 Ethical Aspect**

A thorough investigation of this nature necessitates careful consideration of ethical dilemmas. Ensuring the safety and security of study participants is a fundamental entitlement, and researchers are fully dedicated to protecting them. Ensuring informed consent from participants, upholding privacy and anonymity, limiting potential pain or injury, and clearly outlining research techniques are all crucial ethical considerations in this study (Nitzl et al., 2016). Before commencing the research, it is necessary to

obtain ethical approval from the relevant ethics commission. If researchers adhere to the criteria, they can have confidence in their findings and demonstrate proper treatment of participants by showing decency and respect.

### 3.7 Research Process

Figure 01 shows the overall research process used for this research.



**Figure 3.1: Research Process**

### **3.8 Chapter Summary**

The research strategy employed in this study has been elucidated in this chapter. To attain the objective, it further provided commentary on the actions implemented during the study. There were two stages in the data collecting process. To achieve the goals quantitative research approach has been used. Data was collected in two phases, utilizing a preliminary survey and then a questionnaire survey. Subsequently, collected data was subjected to statistical analysis.

## CHAPTER 04 – DATA COLLECTION AND ANALYSIS

### 4.1 Chapter Introduction

The data gathering, analysis, study findings, and discussion are all covered in this chapter. To answer the research questions or test the hypotheses, collected data have been offered in this chapter. The study will discuss the investigation results and explain how the study arrived at those conclusions in the following sections. The results were well-organized, with tables, charts, and graphs used to succinctly explain facts. The goal is to add to the current literature by providing a full and accurate result analysis.

After analyzing the respondents' feedback, the KPIs were ranked using the Relative Importance Index method. Relative Importance Indices (RII) for each factor were created using a Likert Scale, which goes from low significant (Scale=1) to highly significant (Scale=5), as demonstrated by Eq. 1.

$$RII = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{AN} \quad \text{Eq. 1}$$

In this equation,

$n_1$  – Responders to “Strongly agree”

$n_2$  – Responders to “Agree”

$n_3$  – Responders to “Neutral”

$n_4$  – Responders to “Disagree”

$n_5$  – Responders to “Strongly Disagree”

In this equation N is total respondents (45 relevant to this study), A is maximum weight (5 relevant to this study). Table 06 illustrates the five degrees of significance that have been assigned to the RII value, which ranges from 0 to 1 (0 not inclusive). The RII figure was divided into two categories, "accept" and "reject," to establish the decision rule for determining elements that significantly contribute, as indicated in Table 06. In this analysis,

Highest RII = HRII

Lowest RII = LRII



The range of the RII = HRII-LRII

Scale Index (SI)= (HRII-LRII) / 5

Scale Index was added for each index scale, beginning with the lowest RII score. Only individuals with RII scores between the very substantial and the extremely significant were deemed to have made a significant contribution, according to the decision-making criteria.

**Table 4.1 Decision making Relative Important Index Value**

Scale Index	Index Range	Decision Rule
Not at all significant	LRII – LRII+SI	Reject
Slightly significant	LRII+SI – LRII+2SI	Reject
Somewhat significant	LRII+2SI – LRII+3SI	Reject
Very significant	LRII+3SI – LRII+4SI	Accept
Extremely significant	LRII+4SI – LRII+5SI(HRII)	Accept

The Cronbach alpha is for estimate reliability for items on the Likert scale assessing the reliability of the scale used to measure the construct of interest. As seen in Eq. 2, the weighted standard variations mean, or Cronbach alpha coefficient is derived through dividing summation of items in the scale by the general variance. The dependability degree of acceptance for the Cronbach alpha coefficient is displayed in Table 07.

$$A = \frac{K * \sum S^2Y}{K-1 \sum S^2X} \quad \text{Eq.2}$$

K: Number of items

S<sup>2</sup>Y: Sum of Items Variances

S<sup>2</sup>X: Total Variance of the total score

**Table 4.2 Coefficient of Cronbach's alpha and its reliability level**

Coefficient of Cronbach's Alpha	Reliability Level
More than 0.90	Excellent
0.80 - 0.89	Good
0.70 - 0.79	Acceptable
0.60 - 0.69	Questionable
0.50 - 0.59	Poor
Less than 0.5	Unacceptable

## 4.2 Data Analysis

### 4.2.1 Professions of Responders

**Table 4.3 Professions of Responders**

Profession of Responders	
Project Team Leader	1
Project Manager	4
Chief Quantity Surveyor	1
Design Engineer	3
Site Engineer	13
HSE Officer	18
HSE Manager	5
Total	45

The diversity of responder's profession is outlined in the table 4.3. Among the responders 11.1% were project management executives who worked with road construction projects in Sri Lanka. The majority of those who were questioned (51.1%) were Health and Safety executives who worked within the road construction industry. Among the responders 28.9% were site Engineers who responsible for implementing safety arrangements at the construction site.

### 4.2.2 Years of Experience

**Table 4.4 Years of Experience**

Experience Years	
0-2 Years	0
3-5 Years	4
6-10 Years	4
More than 10 years	37
Total	45

The diversity of years of experience held by the sample members is outlined in the table 4.4. While a sizeable minority (4.9%) of individuals who were questioned had

just three to five years of experience, the majority of those who were questioned (82.2%) had more than ten years of experience. When invalid or missing replies have been removed, the valid percent column information represents the proportion of total respondents who fall into each group. The cumulative per cent column shows the percentages of people who have replied to the poll up to this point. Most respondents, 82.2% of the total, and the other respondents (who had between 3 and 10 years of experience) said they had more than ten years of experience.

#### 4.2.3 Employment Status

**Table 4.5 Employment status**

Status of the Employment	
Employed full-time	37
Employed part - time	2
Self employed	1
Unemployed and looking for work	5
Unemployed and not looking for work	0
Retired	0
Other	0
Total	45

Table 4.5 depicts the distribution and percentage of participants' job statuses. 37 (82.2%) of the 45 participants are presently employed full-time, 2 (4.4%) work part-time, 1 (2.2%) are self-employed, and 5 (11.1%) are jobless and searching for employment. When the incorrect replies have been deleted, the remaining percentage distribution may be viewed in the valid% column. The "cumulative percentage" column represents the overall proportion of valid replies at that time.

### 4.3 Reason for Existing Safety Issues in Road Construction in Sri Lanka

Following table shows the questionnaires data response and RII values for reason for existing safety issues in Sri Lankan road construction industry.

**Table 4.6 RII Rank for Questionnaire Responds to Reason for Existing Safety Issues in Road Construction in Sri Lanka**

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	RII	Rank
Q1) Poor allocation for the personal protective equipment.	0	1	10	20	14	0.809	5
Q2) Lack of consideration by the top management.	0	0	5	21	19	0.862	2
Q3) Ignorance by the site Engineer and other technical staff.	0	0	6	26	13	0.831	3
Q4) Difficulties in getting experienced workers because of low salaries	0	3	30	9	3	0.653	8
Q5) Lack of site co-ordination	0	0	11	19	15	0.818	4
Q6) Lack of consideration by the client and Engineers	0	0	3	21	21	0.880	1
Q7) No proper safety policy available for the organization	0	3	19	21	2	0.698	7
Q8) Lack of adequate knowledge and skills	0	2	20	15	9	0.751	6

**Table 4.7 Sum of Item Variances - Reason for Existing Safety Issues in Road Construction in Sri Lanka**

Question No	Number of Participants	Min Value	Max Value	Total Value	Variance
Q1	45	2	5	182	0.620
Q2	45	3	5	194	0.437
Q3	45	3	5	187	0.398
Q4	45	2	5	147	0.462
Q5	45	3	5	184	0.570
Q6	45	3	5	198	0.373
Q7	45	2	5	157	0.472
Q8	45	2	5	167	0.650
Sum of Item Variances					3.982

**Table 4.8 Variance of the total score - Reason for Existing Safety Issues in Sri Lankan Road construction Industry**

Respondent No	Total Value	Respondent No	Total Value	Respondent No	Total Value
P1	31	P16	29	P31	29
P2	28	P17	35	P32	29
P3	29	P18	32	P33	29
P4	29	P19	31	P34	29
P5	35	P20	35	P35	30
P6	29	P21	24	P36	35
P7	35	P22	32	P37	31
P8	31	P23	32	P38	35
P9	30	P24	36	P39	33
P10	34	P25	30	P40	30
P11	32	P26	31	P41	34
P12	32	P27	31	P42	29
P13	34	P28	33	P43	31
P14	33	P29	31	P44	30
P15	35	P30	35	P45	28
<b>Minimum Value</b>					<b>24</b>
<b>Maximum Value</b>					<b>36</b>
<b>Number of Items</b>					<b>45</b>
<b>Variance of the total Score</b>					<b>6.56</b>

**Table 4.9 Cronbach's alpha value for Questionnaire Responds to Reason for Existing Safety Issues in Sri Lankan Road Construction Industry**

K (Number of Question)	8
S <sup>2</sup> Y: Sum of Items Variances – sum of Variances for each Question responded by different participants	3.982
S <sup>2</sup> X: Variance of the total score – Variance for sum of individual respondent for different questions	6.560
Cronbach's Alpha (A)	0.694

$$A = \frac{K * \sum S^2Y}{K-1 \sum S^2X} \quad \text{Eq.2}$$

$$A = \frac{8 * 3.982}{(8-1) * 6.560}$$

$$A = 0.694$$

Cronbach's alpha will determine the questionnaire's internal consistency or how well independent questions evaluate the same thing. For this research questions, Cronbach's alpha is 0.694. As per the Table 4.2 – Cronbach's alpha should be exceeded 0.69. Hence it is Acceptable.

To calculate the scale index and develop the decision rule Table 4.1 shall be used

$$\text{Highest RII} = 0.880$$

$$\text{Lowest RII} = 0.653$$

$$\text{Range} = 0.880 - 0.653 = 0.027$$

$$\text{Scale Index} = 0.027 / 5 = 0.04533$$

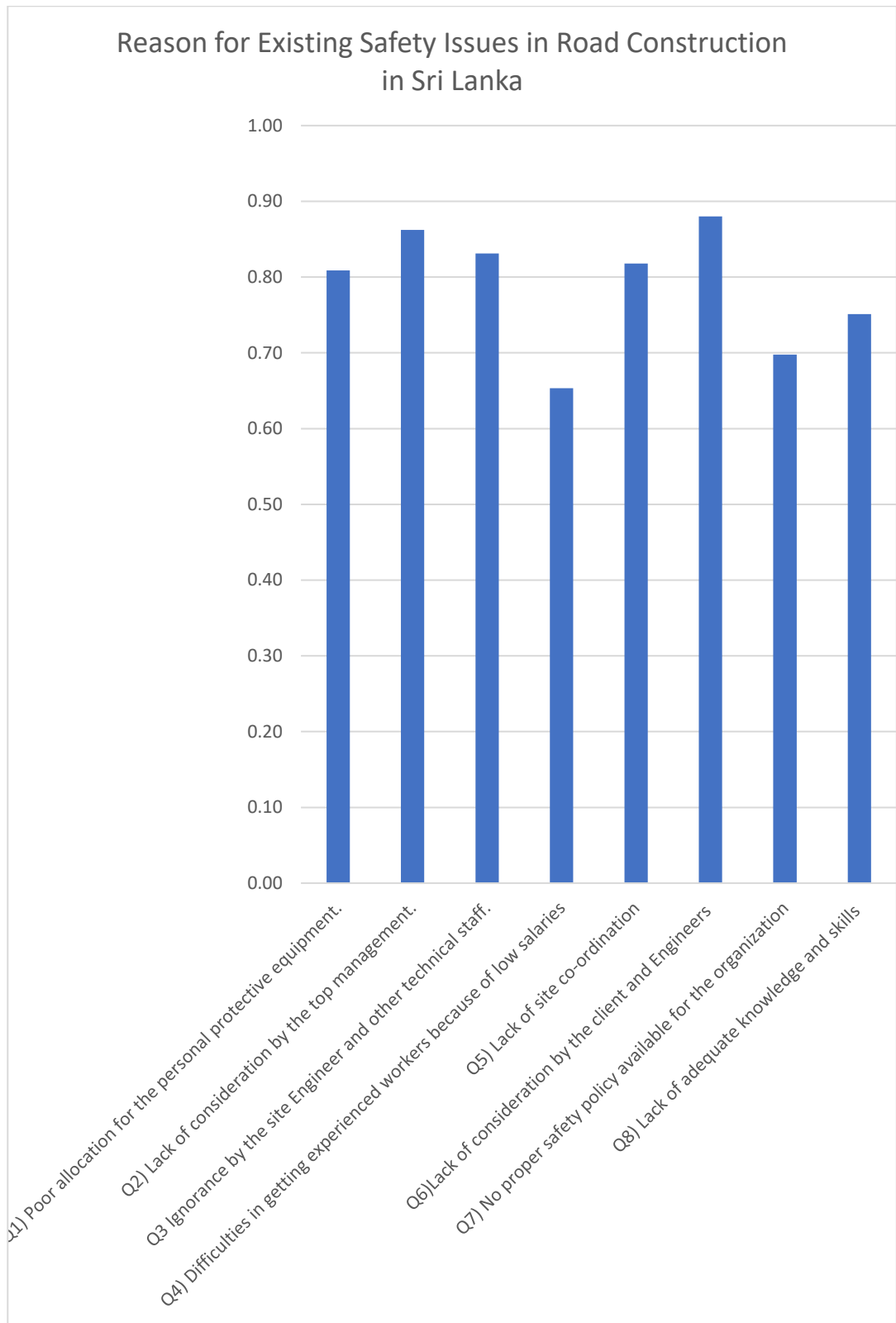
**Table 4.10 Decision making Relative Important Index Value for Reason for Existing Safety Issues**

Index Range	Decision Rule
0.653 - 0.699	Reject
0.700 - 0.744	Reject
0.745 - 0.789	Reject
0.790 - 0.835	Accept
0.836 - 0.880	Accept

According to the RII ranking Lack of consideration by the client and Engineers will be considered as most significant reason for existing safety issues in Sri Lanka Road construction industry.

To check the validity RII value should be exceeded 0.790. in this scenario Q1) Poor allocation for the personal protective equipment, Q2) Lack of consideration by the top management, Q3 Ignorance by the site Engineer and other technical staff, Q5) Lack of site co-ordination, also could be accepted.





**Figure 4.1 Reason for Existing Safety Issues in Sri Lankan Road construction Industry**

#### 4.4 Data Analyzing – Factors Contributing to Existing Safety Issues in Sri Lankan Road Construction Industry

Following table shows the questionnaires data response and RII values to analyze Factors Contributing the Safety in Sri Lankan Road Construction Industry.

**Table 4. 11 RII Rank for Questionnaire Responds to Factors Contributing to Existing Safety Issues in Road Construction in Sri Lanka**

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	RII	Rank
Q1) Lack of health and safety rules and regulations	0	21	18	4	2	0.542	8
Q2) Attitudes and behaviors toward safety	0	0	6	15	24	0.880	2
Q3) Inadequate training	0	0	7	24	14	0.831	4
Q4) Poor site management	0	1	4	21	19	0.858	3
Q5) Night time work	0	0	26	11	8	0.720	6
Q6) Use of incorrect construction techniques	0	9	25	6	5	0.631	7
Q7) Lack of enforcement of safety regulations	0	0	3	14	28	0.911	1
Q8) Hiring of incompetent personnel	0	2	24	8	11	0.724	5

**Table 4.12 Sum of Item Variances - Factors Contributing to Existing Safety Issues in Road Construction in Sri Lanka**

Question No	Number of Participants	Min Value	Max Value	Total Value	Variance
Q1	45	2	5	122	0.650
Q2	45	3	5	198	0.507
Q3	45	3	5	187	0.442
Q4	45	2	5	193	0.517
Q5	45	3	5	162	0.596
Q6	45	2	5	142	0.754
Q7	45	3	5	205	0.380
Q8	45	2	5	163	0.813
Sum of Item Variances					4.658

**Table 4.13 Variance of the total score - Factors Contributing to Existing Safety Issues in Sri Lankan Road Construction Industry**

Respondent No	Total Value	Respondent No	Total Value	Respondent No	Total Value
P1	30	P16	30	P31	30
P2	32	P17	32	P32	31
P3	26	P18	30	P33	33
P4	30	P19	30	P34	27
P5	31	P20	34	P35	28
P6	29	P21	33	P36	30
P7	32	P22	31	P37	28
P8	26	P23	29	P38	33
P9	27	P24	28	P39	29
P10	35	P25	31	P40	30
P11	32	P26	29	P41	32
P12	28	P27	28	P42	29
P13	31	P28	33	P43	32
P14	37	P29	31	P44	32
P15	28	P30	33	P45	32
Minimum Value					26
Maximum Value					37
Number of Items					45
Variance of the total Score					5.36

**Table 4.14 Cronbach's alpha value for Questionnaire Responds to Factors Contributing to Existing Safety Issues in Road Construction in Sri Lanka**

K (Number of Question)	8
S <sup>2</sup> Y: Sum of Items Variances – sum of Variances for each Question responded by different participants	4.658
S <sup>2</sup> X: Variance of the total score – Variance for sum of individual respondent for different questions	5.361
Cronbach's Alpha (A)	0.993

$$A = \frac{K * \sum S^2Y}{K-1 \sum S^2X} \quad \text{Eq.2}$$

$$A = \frac{8 * 4.658}{(8-1) * 5.361}$$

$$A = 0.993$$

Cronbach's alpha will determine the questionnaire's internal consistency or how well independent questions evaluate the same thing. For this research questions, Cronbach's alpha is 0.993 As per the Table 4.2 – Cronbach's alpha should be exceeded 0.69. Hence it is Acceptable.

To calculate the scale index and develop the decision rule Table 4.1 shall be used

$$\text{Highest RII} = 0.911$$

$$\text{Lowest RII} = 0.542$$

$$\text{Range} = 0.911 - 0.542 = 0.369$$

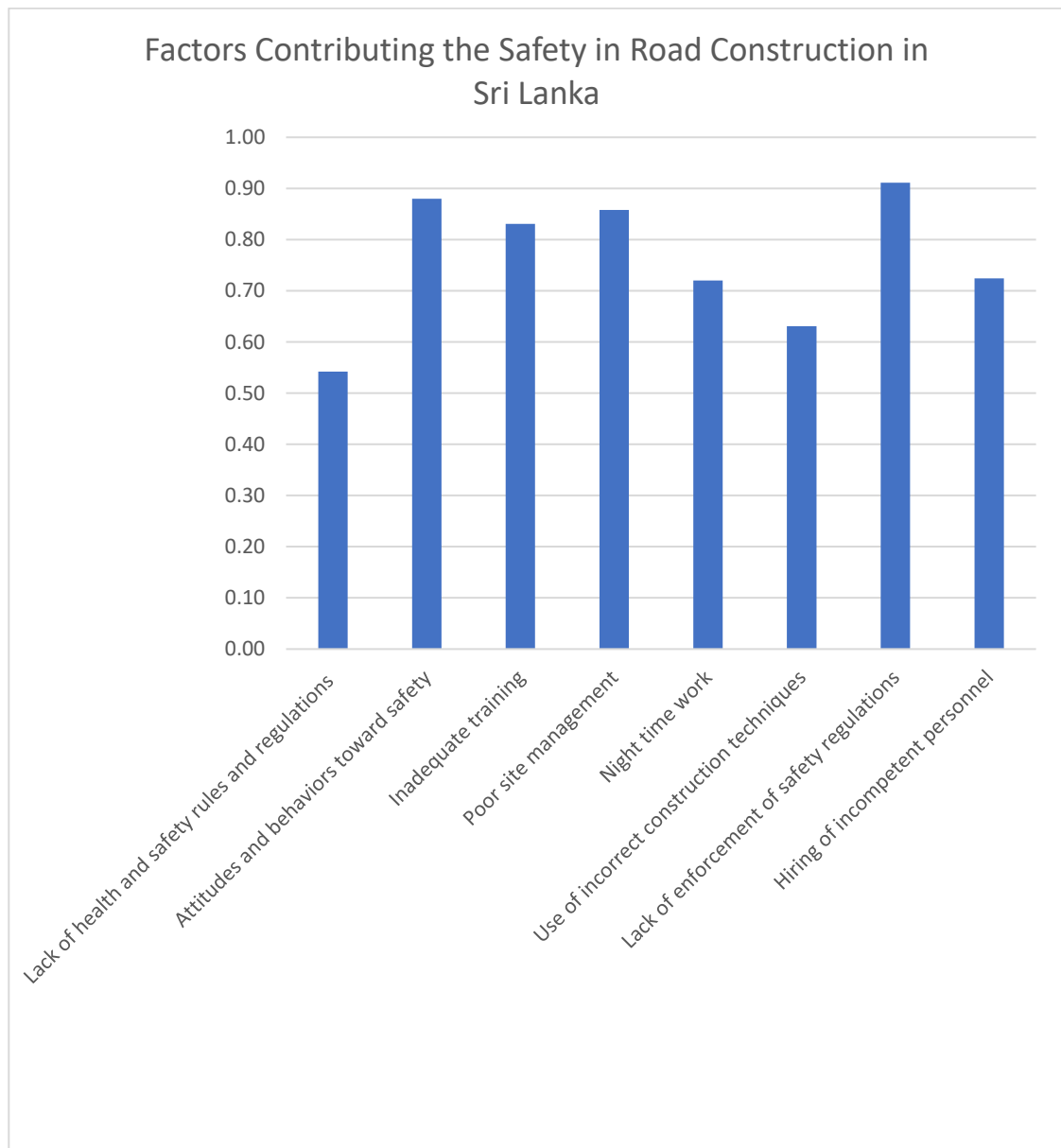
$$\text{Scale Index} = 0.227/5 = 0.07378$$

**Table 4.15 Decision making Relative Important Index Value for Factors Contributing the Existing Safety Issues**

Index Range	Decision Rule
0.542 – 0.616	Reject
0.617 – 0.690	Reject
0.691 – 0.764	Reject
0.765 – 0.837	Accept
0.838 – 0.911	Accept

According to the RII ranking Lack of enforcement of safety regulations will be considered as most significant reason for existing safety issues in Sri Lanka Road construction industry.

To check the validity RII value should be exceeded 0.765. in this scenario Q2) Attitudes and behaviors toward safety, Q3) Inadequate training, Q4) Poor site management also could be accepted.



**Figure 4.2 Factors Contributing to Existing Safety Issues in Sri Lankan Road Construction Industry**

## 4.5 Data Analyzing - Potential Solutions for the Safety Issues in in Road

### Construction in Sri Lanka

Following table shows questionnaires data response and RII values to identify potential solutions for the Safety in road construction in Sri Lanka.

**Table 4.16 RII Rank for Questionnaire Responds to Potential Solutions for the Safety Issues in in Road Construction in Sri Lanka**

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	RII	Rank
Q1) Develop adequate rules and regulations	0	1	32	8	4	0.667	7
Q2) Provide pre-safety training before starting the construction project	0	0	25	16	4	0.707	6
Q3) Penalties for non-adherence to reduce health and safety risks	0	0	4	13	28	0.907	2
Q4) Undertaking and assisting with inspections and academic programs, and research in OSH by the government.	0	0	10	28	7	0.787	5
Q5) Use of advance technology	0	10	26	7	2	0.604	8
Q6) Increasing the number of safety inspections in road construction sites by authorities	0	0	6	25	14	0.836	4
Q7) Increasing funding for safety measures and equipment.	0	0	1	9	35	0.951	1
Q8) Providing incentives for companies that prioritize safety in their road construction projects.	0	0	3	16	26	0.902	3

**Table 4.17 Sum of Item Variances - Potential Solutions for the Safety Issues in in Road Construction in Sri Lanka**

Question No	Number of Participants	Min Value	Max Value	Total Value	Variance
Q1	45	2	5	150	0.444
Q2	45	3	5	159	0.427
Q3	45	3	5	204	0.427
Q4	45	3	5	177	0.373
Q5	45	2	5	136	0.555
Q6	45	3	5	188	0.413
Q7	45	3	5	214	0.229
Q8	45	3	5	203	0.383
Sum of Item Variances					3.2514

**Table 4.18 Variance of the total score - Potential Solutions for the Safety Issues in Sri Lankan Road Construction Industry**

Respondent No	Total Value	Respondent No	Total Value	Respondent No	Total Value
P1	30	P16	30	P31	34
P2	31	P17	31	P32	33
P3	37	P18	32	P33	32
P4	31	P19	29	P34	34
P5	28	P20	34	P35	31
P6	32	P21	34	P36	30
P7	31	P22	25	P37	31
P8	32	P23	32	P38	35
P9	31	P24	31	P39	32
P10	33	P25	31	P40	35
P11	30	P26	32	P41	31
P12	31	P27	32	P42	30
P13	33	P28	31	P43	34
P14	32	P29	31	P44	31
P15	37	P30	33	P45	31
Minimum Value					28
Maximum Value					37
Number of Items					45
Variance of the total Score					4.43

**Table 4.19 Cronbach's alpha value for Questionnaire Responds to Potential Solutions for the Safety Issues in in Road Construction in Sri Lanka**

K (Number of Question)	8
S <sup>2</sup> Y: Sum of Items Variances – sum of Variances for each Question responded by different participants	3.251
S <sup>2</sup> X: Variance of the total score – Variance for sum of individual respondent for different questions	4.427
Cronbach's alpha	0.839

$$A = \frac{K * \sum S^2Y}{K-1 \sum S^2X} \quad \text{Eq.2}$$

$$A = \frac{8 * 3.251}{(8-1) * 4.427}$$

$$A = 0.839$$

Cronbach's alpha will determine the questionnaire's internal consistency or how well independent questions evaluate the same thing. For this research questions, Cronbach's alpha is 0.839 As per the Table 4.2 Cronbach's alpha should be exceeded 0.69. Hence it is Acceptable.

To calculate the scale index and develop the decision rule Table 4.1 shall be used

$$\text{Highest RII} = 0.951$$

$$\text{Lowest RII} = 0.604$$

$$\text{Range} = 0.951 - 0.604 = 0.347$$

$$\text{Scale Index} = 0.347/5 = 0.06933$$

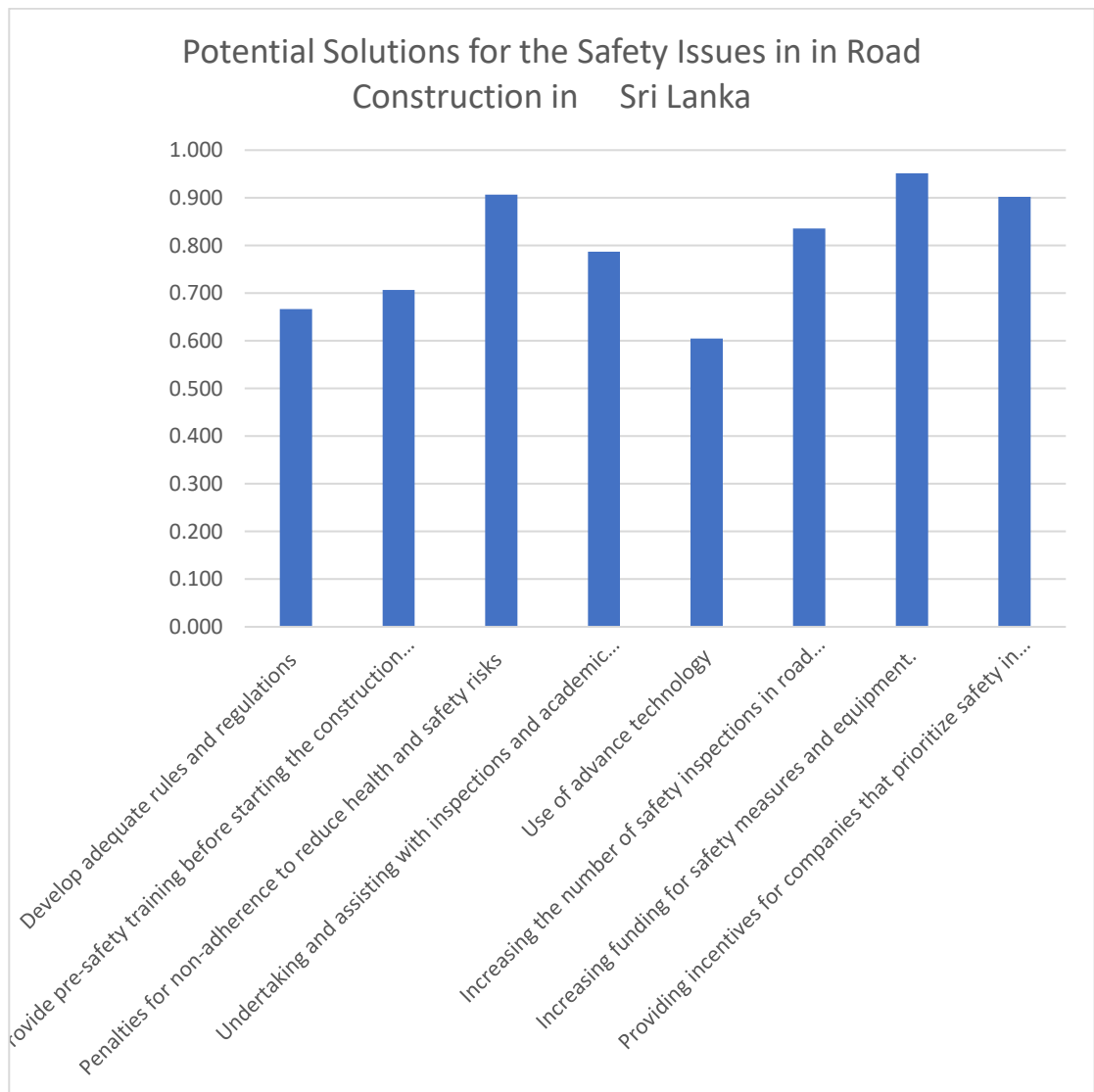
**Table 4.20 Decision making Relative Important Index Value for Potential Solutions for the Safety Issues**

Index Range	Decision Rule
0.604 – 0.674	Reject
0.675 – 0.743	Reject
0.744 – 0.812	Reject
0.813 – 0.882	Accept
0.883 – 0.951	Accept



According to the RII ranking Increasing funding for safety measures and equipment will be considered as most significant reason for existing safety issues in Sri Lanka Road construction industry.

To check the validity RII value should be exceeded 0.813. in this scenario Q3) Penalties for non-adherence to reduce health and safety risks, and Q8) Providing incentives for companies that prioritize safety in their road construction projects and Q6) Increasing the number of safety inspections in road construction sites by authorities also could be accepted.



**Figure 4.3 Potential Solutions for the Safety Issues in in Road Construction in Sri Lanka**

#### **4.6 Chapter Summary**

This chapter contains the findings from the data analysis. The process of collecting the study's data was divided into two phases. Four health and safety executives who work on road construction projects assisted in the development of a survey questionnaire. Content analysis was used to review the data and enhance the survey's main questions. A questionnaire survey was also given to 45 construction executives who were involved in road projects in Sri Lanka in order to find out about any safety concerns. After that, the data was assessed, and questions were posed to construction executives to find solutions to the identified problems. Using RII, the data that was gathered was examined. Thus, this chapter included the study results regarding the present status of safety concerns in road construction in Sri Lanka.

## **CHAPTER 05 – CONCLUSIONS**

### **5.1 Chapter Introduction**

In this chapter of the key findings and insights garnered throughout the investigation are summarized. The study aimed to comprehensively assess the safety challenges faced by workers during road construction activities in Sri Lanka, while also proposing recommendations for mitigating these risks.

It was commenced by providing an overview of the importance of road construction in Sri Lanka's development agenda, highlighting its significant impact on economic growth and societal well-being. Throughout the research, it was identified several primary safety issues plaguing road construction sites in Sri Lanka. These included poor attitudes towards safety, insufficient training, ineffective site management, lack of knowledge among site engineers and technical staff, inadequate provision of personal protective equipment, insufficient attention from top management, and a failure to enforce safety regulations. Enforcing penalties for non-compliance with safety measures, offering rewards to companies that prioritize safety in road construction projects, and conducting more safety inspections at road construction sites by authorities all contribute to improving road construction safety in Sri Lanka.

### **5.2 Objective Achievement**

#### **5.2.1 Objective 01 - Review the Safety Issues in Road Construction in A Global Context and Sri Lanka.**

Through a comprehensive analysis of the available data on road safety internationally, this study aimed to identify and evaluate the safety issues associated with Sri Lankan road construction and globally. The findings suggest that doing a comprehensive literature study on global road safety concerns is advisable. This demonstrates a keen interest in delving deeper into the existing knowledge and research on the issue to provide a solid basis for future breakthroughs and to identify significant obstacles and potential solutions. Upon analyzing prior research on road construction safety difficulties, many key factors were discovered. These factors include unreported dangers, a lack of information and awareness of safety issues, and a deficiency in

skills. An analysis of the situation reveals several concerning factors: the employee's limited capacity to evaluate operational hazards, instances of horseplay, insufficient safety facilities and equipment, and a disregard for safety norms, failure to adhere to safety protocols and the presence of faulty equipment, lack of guards, substandard working condition, incorrect utilization of the instrument, non-compliance with the use of PPE, absence of safety information, The job exhibits a lack of structure, inadequate housekeeping, and unacceptable work habits. Engaging in tasks that include lifting heavy objects, working in uncomfortable positions, and using unsafe lifting gear and methods all pose potential risks. The inadequate insulation of electrical components and the need for maintenance, while machinery is in operation, are two critical factors that should be addressed.

### **5.2.2 Objective 02 – Explore the Reasons for Existing Safety Issues in the Sri Lankan Road Construction Industry.**

Analyze the underlying causes of the existing safety issues in road construction was the second objective. Based on studies, it is widely believed by construction executive that the main reason for present safety issues is inadequate attention from the client and engineers. The distribution of personal protective equipment is ineffective, senior management shows apathy, the site engineer and other technical personnel display ignorance, site coordination is inadequate, and there are reasonable causes for the continuous safety concerns in the sector.

### **5.2.3 Objective 03 – Identify the Factors Contributing Safety Issues in the Sri Lankan Road Construction Industry.**

The third objective was to identify the underlying reasons for the existing safety issues in road construction. The findings indicate that several variables contribute to the decreased safety standards observed at road construction sites. The factor analysis reveals that Sri Lankan road construction industry is now encountering safety non-compliances, with the key reason being the implementation of safety regulations. Attitudes and actions towards safety, insufficient training, and poor site management are all notable elements that contribute to the safety difficulties listed.

#### **5.2.4 Objective 04 – Propose Solutions for Safety Issues in Sri Lankan Road Construction Industry**

Objective 4 for present potential strategies that can be employed to improve safety in Sri Lankan road construction industry. As per research findings most respondents believe that the safety situation of Sri Lankan road construction industry can be improved by increasing financing for safety measures and equipment.

Identified as potential solutions for enhancing safety within the industry are penalties for non-adherence to reduce health and safety risks, incentives for companies that prioritize safety in their road construction projects, and frequent site safety inspection by the authorities.

### **5.3 Recommendations**

The following proposals are derived from the results obtained, and aimed at enhancing road safety in Sri Lanka. It is imperative to increase funds for safety measures and equipment to enhance the safety standards of road development in Sri Lanka. Likewise, respondents have proposed that offering incentives to enterprises that give priority to safety in their road construction projects can effectively address safety concerns in the sector. These two aspects are likely to contribute to the resolution of financial obstacles in construction a secure construction site. Moreover, this would guarantee that all construction workers had prompt access to and were provided with instructions on utilizing any necessary safety equipment.

Possible strategies for addressing safety problems in road construction involve recommending that authorities enhance the frequency of safety inspections conducted at construction sites and enforce fines for noncompliance to mitigate risks to health and safety. The primary legislation that applies to Occupational Safety and Health in the road construction sector in Sri Lanka is the factories ordinance and workmen's ordinance. In addition, a significant portion of road development projects is primarily financed by international organizations such as the ADB, JICA, World Bank, and Exim Bank. Many financing agents have established their safety criteria and monitoring procedures that must be implemented at project sites. However, it is often the case that

these projects and construction companies have been unable to meet these safety criteria. Hence, it is imperative for authorities such as the labor department and project clients, often the RDA, to regularly do site safety audits. These audits are necessary to guarantee that both the project and the contractors are following safety requirements. Additionally, any non-compliance issues that are identified must be promptly addressed within a specified timeframe. Imposing fines for safety infractions would enhance effectiveness by influencing contractors to adhere to safety regulations more diligently.

To achieve the aforementioned goals, it would be beneficial for the government to initiate educational initiatives aimed at raising knowledge on the need to implement safe construction techniques during road construction. The need to ensure traffic safety in construction zones and utilize appropriate traffic controls will also be highlighted (OSH, 2010). It is imperative to enhance the training provided to employees in road construction. Employees need to provide clear instructions to their colleagues on the proper usage of safety equipment and adherence to business procedures. It is important to provide workers with information on the hazards associated with construction and the necessary precautions to mitigate them. Enhancing communication among construction businesses, clients, and government agencies is necessary to build a system for monitoring safety processes in the construction sector and providing feedback as necessary. As a result, issues will be addressed promptly and effectively (Al-Thani et al., 2015). The data strongly suggests the need for more investigation into road safety in Sri Lanka. This will enable us to delve deeper into the difficulties and develop more efficient solutions. To effectively tackle Sri Lanka's road safety concerns, the government, the construction sector, and the public must collaborate and work in unison. The research's findings ultimately contributing safer working environments for the working crew.

The study's findings provide valuable insights into the road safety issues in Sri Lanka, revealing several factors that contribute to these difficulties. The study's results and suggestions can be utilized to mitigate the risk of damage to personnel. To guarantee safety of worker and the public, it is imperative for all participants in Sri Lanka's road construction industry to proactively address any current safety issues (Priest 2012).

Construction experts need to employ the findings of the study to improve worker safety on road construction sites. In general, the results highlight the importance of continuing and expanding research on road construction safety.

#### **5.4 Implications**

There are several approaches via which the findings of this study might be utilized to enhance road safety in Sri Lanka. Worker safety should be the priority for any road construction project. To achieve this objective, it may be necessary to establish safety protocols, provide safety training to personnel, and ensure the provision of necessary equipment and protective gear. The project manager is accountable for implementing and enforcing all safety protocols during the construction process. Furthermore, research findings show additional studies to be done to investigate fundamental elements that contribute to Sri Lanka's road safety issues. Further research might examine the effectiveness of current safety procedures and other methods for construct more secure roads. The study demonstrates the crucial importance of cultivating a safety culture within the construction industry, which prioritizes collaboration and a collective dedication to health and safety. Additionally, it highlights the necessity of effectively coordinating the actions of government agencies, contractors, and employees to ensure the safety of road construction projects. The findings of this study can be utilized by other developing nations to enhance the safety of the industry. Identifying practical solutions and analyzing the root causes of safety concerns are abilities that may be applied in various contexts. In conclusion, the findings and recommendations of this study significantly enhance our understanding of and capacity to tackle road safety concerns in Sri Lanka and has the potential to decrease fatalities by implementing the above recommendations.

#### **5.5 Future Research Directives**

This study offers valuable insights into the road safety concerns in Sri Lanka and potential solutions, despite the need for further research. Conducting an evaluation on contributing factors to road construction accidents and injuries is essential before examining the attitudes and actions of workers and management toward safety standards. It is possible to assess the existing safety laws and recommendations to see if they may be enhanced by more studies. To enhance road construction safety,

potential areas of technical study might focus on exploring the utilization of state-of-the-art construction equipment and implementing virtual reality training programs for staff members. It would be intriguing to do a comparative analysis of the best practices and safety issues in different locations. This has the potential to facilitate the development of targeted and effective measures aimed at improving road safety in Sri Lanka and other nations facing comparable challenges. The study's findings establish a structure for further exploration of safety concerns in Sri Lanka's Road construction industry, highlighting the importance of ongoing endeavors to enhance safety procedures and mitigate the recurrence of safety-related issues in the sector.



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## APPENDICES

Research Project – An Analysis of the Safety Issues in Road Construction in Sri Lanka.

Questionnaire

Section 1

1. Name of the Respondent (Optional) .....
  2. Name of the Organization (Optional) .....
  3. Designation .....
  4. Experience in construction industry.....
    - 0-2 Years
    - 3-5 Years
    - 6-10 Years
    - More than 10 Years
  5. What is your employment status .....
- Employed full-time
  - Employed part-time
  - Self-employed
  - Unemployed and looking for work
  - Unemployed and not looking for work
  - Retired

## Section 2

Please indicate the extent to which you think the following cause to prevail safety issues in the context of road construction in Sri Lanka. (Reason for Existing Safety Issues in Road Construction in Sri Lanka)

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Q1) Poor allocation for the personal protective equipment.					
Q2) Lack of consideration by the top management.					
Q3) Ignorance by the site Engineer and other technical staff					
Q4) Difficulties in getting experienced workers because of low salaries					
Q5) Lack of site co-ordination					
Q6) Lack of consideration by the client and Engineer					
Q7) No proper safety policy available for the organization					
Q8) Lack of adequate knowledge and skill					

### Section 3

Please indicate the extent to which you think the following factors contribute to exist safety issues in the context of road construction in Sri Lanka. (Factors Contributing the Safety in Road Construction in Sri Lanka)

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Q1) Lack of health and safety rules and regulations					
Q2) Attitudes and behaviors towards safety					
Q3) Inadequate training					
Q4) Poor site management					
Q5) Night time work					
Q6) Use of incorrect construction techniques					
Q7) Lack of enforcement of safety regulations					
Q8) Hiring of incompetent personnel					

#### Section 4

Please indicate the extent to which you think the following solutions contribute to enhance safety in road construction in Sri Lanka. (Potential Solutions for the Safety Issues in Road Construction in Sri Lanka)

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Q1) Develop adequate rules and regulations					
Q2) Provide pre-safety training before starting the construction project					
Q3) Penalties for non-adherence to reduce health and safety risk					
Q4) Undertaking and assisting with inspections and academic programs, surveys and research in occupational safety and health field by the government.					
Q5) Use of advance technology					
Q6) Increasing the number of safety inspections in road construction site by authorities					
Q7) Increasing funding for safety measures and equipment					
Q8) Providing incentives for companies that prioritize safety in their construction projects					