London South Bank University

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Developing Toolkits and Guidelines to Improve Safety Performance in the Construction Industry in Oman

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A thesis submitted in partial fulfillment of the requirements of London South Bank University for the degree of Doctor of Philosophy in Construction Management

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Declaration

I confirm that this work has not been submitted for an award of a degree or diploma in any university. The thesis does not contain any material previously published or written by another author except where due references are made in the thesis itself.

Tariq Umar

June 2019

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Contents

List of Tables:

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Abbreviations:

ABS: Australian Bureau of Statistics

ACSA: Alberta Construction Safety Association

AHA: American Heart Association

AIChE: American Institute of Chemical Engineers

APA: American Psychological Association

AUS: Australia

AWI: Alternate Work Injury

BERA: British Educational Research Association

BLS: Bureau of Labour Statistics

BMI: Body Mass Index

BP: Blood Pressure

BPA: Blood Pressure Association

BPS: British Psychology Society

CDCP: Centers for Disease Control and Prevention

CDM: Construction Design and Management

CIB: International Council for Research and Innovation in Building and Construction

CIC: Construction Industry Council

CISCIS: Construction Industry Safety Climate Index Software

CPWR: Center for Protection of Worker's Right

CWCP: Construction Work Code of Practice

DGM: Directorate General of Meteorology

DH: Department of Health

EUCS: European Union Construction Sector

FAI: First Aid Injury

GCC: Gulf Cooperation Council

GCHC: Guidance on the Classification of Hazardous Chemicals

GDP: Gross Domestic Product

GOSI: General Organization for Social Insurance

HCSC: Hazardous Chemical Substances Regulations

HSE: Health and Safety Executive

ILO: International Labour Organization

INSAG: International Nuclear Safety Advisory Group

ITUC: International Trade Union Confederation

kg: kilogram

LMRA: Labour Market Regulatory Authority

LTI: Loss Time Injury

m: meter

MD: Muscat Daily

MFI: Movement for Innovation

MHRE: Ministry of Human Resources and Emiratizations

MoM: Ministry of Manpower

MTI: Medical Treatment Injury

NAO: National Audit Office

NCSI: National Center for Statistic and Information

NIOSH: National Institute of Occupational Safety and Health

NRC: National Research Council

NSC: National Safety Council

NTSB: National Transportation Safety Board

OLL: Oman Labor Law

ONS: Office for National Statistics

OSC: Oman Society of Contractors

OSHA: Occupational Safety and Health Administration

OSHR: Occupational Safety and Health regulations

PASI: Public Authority of Social Insurance

PC: Population Clock

RD: Royal Decree

SA: South Africa

SANS: South African National Standards

SD: Sultan’s Decree

SHJ: Statistical Handbook of Japan

SWA: Safe Work Australia

TBO: Tender Board of Oman

TOM: Time of Oman

UK: United Kingdom

USA: United States of America

USAG: Utility Strike Avoidance Group

WHO: World Health Organization

WRI: World Resources Institute

Abstract:

For the past few decades, there have been large infrastructure developments in the Gulf Cooperation Council (GCC) member countries consisting of the main oil and gas exporting countries that include Saudi Arabia, United Arab Emirates, Oman, Bahrain, Kuwait, and Qatar. This rapid growth has attracted international construction organizations and the workforce to the region. At the same time, occupational safety and health remained one of the key issues of the industry in the region. The aim of this research was, therefore, to find the solutions, develop toolkits and guidelines which could help construction organizations in the region to improve their safety performance. This study has considered the key areas of safety that include causes of accidents, costs of accidents, heat stress, occupational safety and health regulations, worker's health factors, and safety climate. There are some studies which considered these areas related to safety and health, but most of these studies are carried out in developed countries which have different environmental and social variables as compared to GCC in general and Oman in specific. For instance, the temperature in Oman in summer reaches 50° C. A toolkit developed for construction workers working in mild temperatures would not be effective for workers working in extreme hot and humid climatic conditions. To achieve the aims of the research associated with these areas, a mixed research method which includes both quantitative and qualitative research methods was adopted.

The accident tracing model developed in this thesis was applied to 623 different types of accidents that took placed in two main construction organizations. The results show that “workers” were the cause of 42% of the total accidents under consideration. Construction organizations will be in a better position when they know the root causes of accidents in their projects. This will help them to develop strategies that encounter such accident causes.

Improved safety performance cannot be achieved without investment in safety. Construction organizations are normally reluctant to spend on safety as they don’t properly understand the financial consequences. It was therefore attempted in this research to estimate the cost of accidents in the GCC construction industry. While there have been some issues in estimating the costs of accidents; however the total costs of an accident in Oman, Saudi Arabia, and Qatar are estimated at US$ 415,620, US$ 91,940 and US$ 205,526 respectively.

GCC region is well known for its hot and humid environment which could heavily affect the workers' performance related to safety and productivity. The interviews held with 20 construction workers involved in different accidents confirm that a hot and humid environment was one of the reasons for the accident in which they were involved. In order to protect workers from heat stress; guidelines have been prepared considering GCC region climatic conditions.

One of the key aspects which can guarantee improved safety performance is the presence of robust occupational safety and health regulations and its implementation. The existing GCC occupational safety and health regulations were compared with the regulations applicable in the USA, UK, AUS, and SA. The discussion revealed that the current regulations in GCC countries related to the (a) Fall from height, (b) Hazard communication standard related to chemicals, (c) Scaffolding, (d) Respiratory protection (e) Control of hazardous energy, (f) Ladders, (g) Powered industrial trucks, (h) Training, (i) Machinery and machine guarding, and (j) Eye and face protection, needs to be updated considering latest industrial requirements and standards.

It is a universal fact that healthy worker's acts will not only make workers safer but such workers will be more productive as well. The results of this study show that the majority of construction workers in the region, based on the results of BMI and BP are not healthy. Similarly, the majority of them reported musculoskeletal pain. Such pain was confirmed to be affecting the worker's productivity. A balanced diet, healthy lifestyle, improved accommodation, workplace facilities and control on tobacco product are some of the key areas which could be considered to improve the workers' health.

Finally, a study has been carried out in the area of safety climate which resulted in a new safety climate assessment tool suitable for the GCC construction industry. The newly developed tool has a total of seven main dimensions including (i) Aligning and Integrating Safety as Value, (ii) Training At all Level, (iii) Improving Site Safety Leadership (iv) Management commitment, (v) Empowering and Involving Workers, (vi) Ensuring Accountability, and (vii) Improving Communication. Brief guidelines have been provided on how to use this assessment tool and how to interpret the results to make plans to achieve the required level of maturity.

The key tools/guidelines developed in this research project were, a) tracing model for the root causes of accidents, b) guidelines for protecting workers from heat stress, c) recommendations for revising occupational safety and health regulations, and d) the safety climate assessment tool. Although, the safety climate assessment tool developed in this research was validated through email interviews, however, longitudinal studies are still recommended to evaluate the effectiveness of the proposed tool.

Chapter 1: Introduction

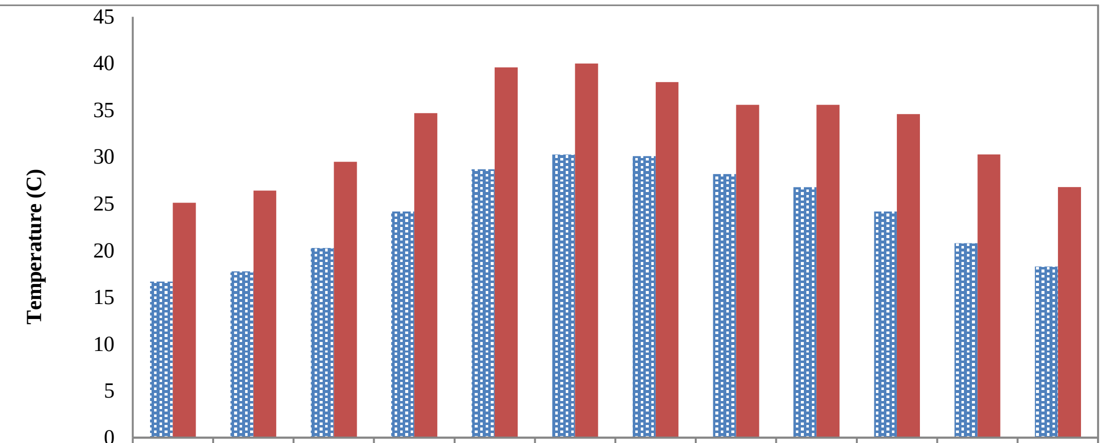
1.1 Introduction:

This is the primary chapter of the thesis which aims to provide an introduction to the research undertaken. The focus of the thesis is on construction safety and health with a specific reference on the GCC region and Oman. Every year a significant portion of the world GDP is spent on the matter arising from the poor occupational safety and health conditions. Construction is among those industries which are classified as most of the hazardous where the risk of accidents is comparatively high particularly in the industries of developing countries. The situation around the safety and health in Oman and other GCC countries is particularly poor due to the lack of knowledge on the causes and costs of accidents, implications of heat stress and workers health of their safety performance, occupational safety, and health regulations, and non-availability of a safety climate assessment tool. This research, therefore, aims to investigate the solutions which could lead to improved safety performance in construction. This chapter introduces the research rationale, aims, and objectives of the research, research methodology and the thesis structure in separate sections. The next section provides a brief overview of the research rationale followed by a detailed description of the research aims and objectives, research methodology and structure of the thesis.

1.2 Research Rationale:

Statistics around safety and health in the construction sector in the GCC region indicate that the situation is comparatively worse when the number of accidents is taken into account. This means that every year the construction sector and the government will have to bear a huge financial cost due to these accidents. There could be several reasons which result in a large number of accidents in GCC construction. These reasons include the lack of the causes of accidents, costs of accidents, the implication of heat stress and workers' health on their safety performance, occupational safety, and health regulations, and non-availability of a safety climate tool for the GCC construction industry. This research, therefore, aims to develop toolkits and guidelines that could be used by the construction organizations in Oman and other GCC countries to improve their safety performance. For instance, what causes an accident or an injury in construction in Oman? If the top management of the construction organizations knows this, they will be able to develop strategies to avoid such causes or factors in their future projects. It is, therefore, necessary that top management of construction organizations know what exactly causes the accidents in construction. For this, construction organizations need to have a toolkit that they can use easily to trace the root causes of accidents and develop strategies to avoid such causes in the future. Accidents in a construction project may not happen on a daily basis, and apparently, management remains reluctant to spend on such issues that don't appear frequently. The main component that management may be ignoring is that although the accidents may not be occurring on regular basis in their projects, however whenever an accident happens the cost of accident such accidents may be overwhelming, greater than the cost of prevention of accident. Thus, it has become important to know the cost of accidents in construction. Similarly, the existence of occupational safety and health regulations and its implementation in a country plays a significant role in the reduction of occupational accidents. For instance, in the United States, worker deaths before the establishment of the Occupational Safety and Health Administration authority in 1970 were 38 per day and this fell to 14 per day in 2016 (OSHA, 2018). This reflects that the presence of occupational safety and health regulations brings a significant improvement in safety performance at the country level. The construction, Design, and Management (CDM) regulations which were enforced first time in 1995, in the United Kingdom were reviewed and amended periodically and the current 2015 CDM regulations are the third version of the actual regulations become effective in 2015 (CDM, 2015). It is clear that the review of the current occupational safety and health regulations on a periodic basis helps countries and organizations to monitor the effectiveness of their regulations and to make necessary changes when required. The benchmarking of a country safety regulations with another country which displays an improved safety performance can help the decision-maker proposed the necessary amendment to the existing regulations. This research project, therefore, aims to benchmark the occupational safety and health regulations in Oman and propose amendments so that the regulations can be brought at par of some of the advanced countries which display improved safety performance.

One of the most important factors which contribute to the performance of workers both in terms of safety and productivity is the worker's wellbeing. Especially when it comes to GCC countries, the hot and humid environment could significantly affect the workers' performance. Indeed studies in different parts of the world indicate that worker's performance is directly linked to environmental conditions such as humidity and temperature (Xiang et al., 2014; Yi and Chan, 2017). Other researchers have also established that the human response process is highly affected by their physical health (Beevers and MacGregor, 1999; Yi and Chan, 2016). The physical health of workers can be easily assessed by their body mass index, blood pressure, and heart rate. There is however no comprehensive study in this area in any GCC country which considered these factors despite the fact that all GCC countries are well known for the extreme hot and humid climatic condition. For instance, the Qatar Meteorology Department data shows that the mean air temperature in Doha in the month of July remains at 35.4^o C, while the mean relative humidity in the same month stands at 49%. Similarly, the highest temperature recorded in 2010, in Doha was 50.4^o C (Meteorology Department, 2018). The official data in Oman shows that the average maximum temperature in Oman reaches 40^o C as shown in figure 1.1 (DGM, 2018). The maximum temperature in Oman reported by different newspapers is so far more than the one reported by official authorities. A news article published in daily newspapers in 2017, reported the maximum temperature in Oman at 50^oC. (MD, 2016). Similarly, another daily newspaper reported that the maximum temperature recorded in Oman in 2015 was 48^o C (TOM, 2015). The effect of heat stress on construction worker's performance in the GCC region, therefore, appears to be more due to extreme environmental conditions as compared to any other part of the world. Similarly, the worker's body pain supplemented by the extensive temperature may have an impact on their response process and can affect their safety and productivity. During the construction process, workers are required to work in an awkward position for a long time. This may significantly contribute to body pain in specific areas. This study, therefore, aims to consider the hot and humid climatic conditions along with the physical parameters of workers such as Body Mass Index, Blood Pressure and Heart Beat and develop guidelines to protect such workers from heat stress.



	January	February	March	April	May	June	July	August	September	October	November	December
Minimum Temperature (°C)	16.7	17.8	20.3	24.2	28.7	30.3	30.1	28.2	26.8	24.2	20.8	18.3
Maximum Temperature (°C)	25.1	26.4	29.5	34.7	39.6	40	38	35.6	35.6	34.6	30.3	26.8

Figure 1. 1: Average Minimum and Maximum Temperature in Oman (DGM, 2018)

While there have been several concepts and methods to improve safety performance and avoid accidents at the construction site, safety culture and safety climate have attracted a large number of researchers and practitioners worldwide due to its significant impact on safety improvement (kines et al., 2011). The concept of safety culture and safety climate gets more appreciation since 1980 when the theories of human age factors were adopted in organization performance. The safety culture represents the overall culture of an organization reflecting how the safety is considered or treated. For example, if safety negligence in organizations is a routine practice, the organization will reflect poor safety culture. Such a culture normally results in a large number of accidents. On the other hand, if an organization's safety is strictly followed and safe acts are appreciated by the management, thus such an organization will display a rich safety culture and the number of accidents will be comparatively low than the organization which holds a poor safety culture. Overall, safety culture is contributed by the workers; however, it is highly influenced by the organization's top management. For example, if the top management gives values to safety and will help to develop a rich safety culture.

Safety climate is a subset of organization climate which is based on the worker's or employee's perceptions. The assessment of safety climate is considered as a barometer of safety culture, therefore a mature safety climate will reflect a rich safety culture (Zohar, 2002). The results of the safety climate can be regarded as more effective as it tells the management very clearly in which dimension the organization needs improvement to achieve the required level of maturity (Kines et al., 2011). Worldwide, there have been several tools developed for the assessment of safety climate which addresses a number of industries including construction. Although, there is no such tool developed or used in the GCC countries. The construction industry in GCC has its own parameters and dimensions. A tool developed and used in the United Kingdom or United States may not be effective in GCC countries due to a variety of factors pertaining to the industry itself. This clearly reflects that there could be a gap in understanding the safety climate factors which may have a high influence on the safety climate in the GCC countries. This research, therefore, aims to develop a safety climate assessment tool that could be used in Oman and other GCC countries.

Keeping in view the above discussion, a number of research aims and objectives are set for this research project which is explained in the next section.

1.2.1 Research Aims:

Considering the current situation of safety and health in the GCC region, this research aims to find solutions that could help construction organizations in the region, particularly in Oman to improve their safety performance. This study, therefore, considered the key areas of safety that include causes of accidents, costs of accidents, heat stress, occupational safety and health regulations, worker's health factors, and safety climate and develop toolkits and guidelines that could be used by construction organizations to improve safety performance. The research objectives set for this research project are outlined in the next section.

1.2.2 Research Objectives:

The overall objective of this research is how safety performance can be improved in construction considering a number of parameters. These parameters are associated with the causes and cost of accidents in construction, occupational safety and health regulations, heat stress, worker's health, and body pain, and safety climate. Each associated parameter thus becomes an individual objective resulting in a total of seven objectives for this research. In brief, these research objectives are mentioned below.

1. To evaluate the causes of accidents from literature and develop a model to trace the causes of accidents.

2. To evaluate and compare the costs of accidents in GCC construction.

3. To investigate the effect of heat stress on the construction worker's safety performance and develop guidelines for protecting workers from heat stress.

4. To benchmark the Occupational Safety and Health Regulations in Oman with advanced countries and identify gaps for improvement.

5. To assess the construction worker's health factors that affect their safety performance.

6. To study the body pain experience of workers and its impact on worker's safety and productivity.

7. To investigate the relevant safety climate factors and develop a safety climate assessment tool for construction organizations.

The next section describes the research methodologies adopted to accomplish the set objectives for this research.

1.3 Research Methodology:

A mix research approach that includes quantitative and qualitative research methods was adopted to achieve the aims and objectives of this research. The complete research methods are explained in chapter 3. Briefly, this research was carried out in a total of four stages including literature review, data collection, data analysis, and writing the thesis.

The next sections describe the different activities of the four stages used to complete this research project. These activities are discussed in more detail in chapter 3.

1.3.1 Stage I: literature review:

1. Background research.

2. Research proposal development, submission, revision, and approval.

3. Development of Data Collection Tools, submission, revision and approval.

a) Interview questionnaire for heat stress.

b) Interview questionnaire for worker's health profile.

c) Interview questionnaire for safety climate factors.

d) Pain assessment questionnaire.

e) Safety climate questionnaire.

4. Finalizing and justification of sample size for different studies.

5. Ethical approval from School Ethical Committee.

6. Selecting and requesting construction organizations for data collection.

1.3.2 Stage II: Data Collection:

1. Visiting the requested organizations and persons for data collection.

2. Selecting the respondents to avoid language barriers where applicable.

3. Briefing the organization's heads and the respondents on the interview process, physical tests such as BMI and blood pressure, etc. where applicable.

4. Assisting the respondents to complete the questionnaire completely.

1.3.3 Stage III: Data Analysis:

1. Checking the collected responses that they are completed and readable before entering into the SPSS (23.0) for processing.

2. Calculating different averages and ratios as part of descriptive analysis. Applying different statistical techniques such as descriptive statistics approach, regression analysis, and content analysis. Applying T-test, One-way analysis of variance (ANOVA), p-vale and Cronbach's alpha coefficient.

1.3.4 Stage IV: Writing the Thesis:

1. Writing up the thesis and submission.

The next section briefly describes the structure of the thesis.

1.4 Scope of the Research:

Considering the aims and objectives of this research, the scope set was to develop toolkits and guidelines for safety improvement in Oman involving data collection from construction workers working in construction organizations registered as grade one and above in Oman. Grade 2 and below organizations were not considered in this study due to the time constraint and due to the fact that most of the construction works (=95%) in Oman are carried out by grade one and above construction organizations. Lower-grade construction companies are normally part of these contracts as sub-contractors, thus overall, this limitation doesn’t affect the generalization of the results presented in this thesis. A detail description of the construction organizations registered in Oman in different grade is provided in section 2.9 of chapter 2 and section 3.3.1 of chapter 3. Similarly, the safety climate toolkits developed were validated through email interviews held with construction professionals in Oman. Longitudinal studies were not carried out due to the time constrain.

1.5 Thesis Structure:

Overall the whole thesis is divided into six chapters explained in figure 1.2.

Chapter 1 is an introduction chapter that indicates the problem by highlighting the key issues associated with construction safety in Oman and other GCC countries. This chapter also derives the research rationale highlighting specific industry and climatic related factors. The rationale of the research considered some of the key elements of the research including, causes and costs of accidents, heat stress and workers' health factors, occupational safety and health regulations and safety climate approach to improve safety performance. A brief of the research methodology adopted to achieve different objectives set for this research project is also given in this chapter. Chapter 1 paved the road for the next chapter by providing elements to focus on.

Chapter 2 of the thesis is a comprehensive chapter on the literature review associated with the aim and objectives of this research project. In general, the literature review chapter has the following sections.

i. Causes of Accidents in Construction

ii. Cost of Accidents in Construction

iii. Heat Stress

iv. Occupational Safety and Health Regulations

v. Worker's health factors

vi. Workers Body Pain

vii. Safety Climate

The literature review chapter also briefly describes the different research methods used in similar research from the literature.

The detail of different research methods used in this research project is explained in chapter 3 entitled “Research Methodology”. This chapter describes and justifies the research design to achieve different objectives of the research. In general two research methods, known as quantitative research methods and qualitative research methods are employed. The chapter explains how the data was collected, analyzed and interpreted. An extensive justification is provided on the selection of respondents and sample size considering the scope of the research and statistical justifications in each research method. The chapter further describes each tool (questionnaire) used in this research project, either it is a structured one or simply the interview one, in detail. The different statistical tests employed in the analysis of the data are explained with their relevance to the objectives of the research. Although the data was collected after the due approval of the Research Ethical Committee of the London South Bank University, the specific ethical guidelines of some of the international organizations are quoted in this chapter.

Chapter 4 of the thesis is the results, analyses and discussion chapter which are divided into many sections and sub-sections. Section 4.1 of chapter 4 is an introduction section. Section 4.2 is related to the “Causes of Accidents in Construction in Oman” which has further five sub-sections. Similarly, section 4.3 describes the “Cost of Accidents in GCC” which is divided into a total of three sub-sections. Heat stress is covered under section 4.4 which has further three sub-sections. Occupational safety and health regulations and construction worker's health factors are covered in sections 4.5 and 4.6 respectively. Discussion on the results and analysis are presented in section 4.7 which has a total of seven sub-sections. The summary of chapter 4 is provided in the last section (section 4.8) of the chapter.

The results, analyses, and discussion of safety climate are described in a separate chapter (chapter 5) which has six main sections five sub-sections. The introduction of chapter five is placed in section 5.1. Analyses and results arising from the systematic literature review are presented in section 5.2. Section 5.3 presents the results and analyses of the semi-structured interview held with professionals working at a managerial position in the construction industry in Oman. This section has further four sub-sections. Analyses and results of the data collected through the questionnaire appended in Appendix II are placed in section 5.4. Section 5.5 explains the newly developed safety climate assessment tool. This section is supported by a sub-section (section 5.5.1) which provides guidelines on how to use and interpret the results of the tool developed in this chapter. Discussion on the results and analysis are presented in section 5.6. The summary of chapter 5 is provided in section 5.6.

Chapter 6 of the thesis provides conclusions and recommendations on the different aspects of the research. Considering the scope of the chapter, it has three main sections. Section 7.1 is the introduction section; follow by section 7.2 which is the conclusion section and finally section 7.3, which is the recommendations section. Chapter 6 also provides an insight into the limitation of the research and highlights the knowledge contribution of the thesis.

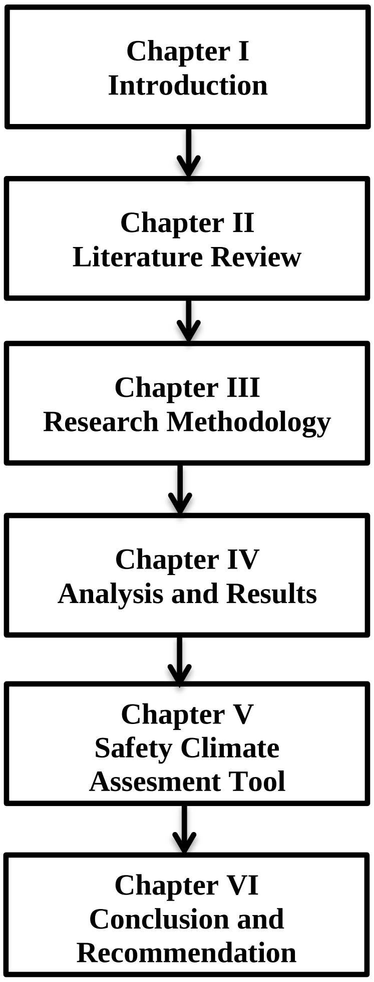


Figure 1. 2: PhD Thesis Structure

The next section of the chapter provides a summary of chapter 1.

1.6 Summary:

Chapter 1 provides an overview of the research project from instruction to the structure of the thesis. The research rationale section indicates that how different parameters such as causes of accidents, cost of accidents, heat stress, occupational safety and health regulations, safety culture, and safety climate could be helpful to achieve a required level of safety performance. The literature review around these parameters is discussed in detail in chapter 2. Chapter 1 also provides the aims and objectives of the research project and the research methodology adopted to achieve these objectives. The detail research methodology is described in chapter 3 of the thesis.

The next chapter of the thesis is the literature review chapter which provides a detailed review of the components associated with the research objective of the thesis.

Chapter 2: Literature Review

2.1 Introduction:

Chapter two of the thesis is the literature review chapter which describes the literature review undertaken in completing this research project. A systematic review approach consistent with the research objectives was adopted to ensure that the gap in the knowledge is effectively identified and that the methodology applied to accomplish the research objectives are best aligned with the existing approaches. The literature review is considered very important in writing research papers and thesis. Randolph (2009) suggested that a defective literature review is one of the many reasons which can derail the thesis, paper or dissertation. A faulty literature review may result in a flawed thesis or dissertation due to the fact that comprehensive research cannot be performed without a full understanding of the existing literature in the relevant area (Boote and Beile, 2005). The literature review of the thesis also gets due considerations by the examiner as well. A research conducted by the Mullins and Kiley (2002) concluded that most of the examiners get a perception of the whole thesis from the literature review. If the literature review is found poor, the examiners assume that the rest of the thesis would also have problems. To ensure that the literature review is best aligned to the research objectives of the project, the literature review is divided into a total of eight sections in this chapter. The aim, objectives and the research rationale discussed in chapter 1 served as a guide to engage with the literature review associated with different parts of the research. The literature review presented in this chapter provided a base to finally proceed towards the development of toolkits and guidelines to improve the safety performance in the construction industry in Oman. It was considered important to start from the construction industry itself; therefore, section 1 of this chapter highlights the construction industry in different countries and regions including Oman. In section 2, the literature review on the causes of accidents in construction is presented. Section 3, of the chapter, presents the literature on the cost of accidents in construction. The literature review on the heat stress and its implication in construction is outlined in section 4. The Occupational Safety and Health Regulations applicable in construction are covered under section 5. In section 6, the construction worker's health factors that affect their safety and productivity performance are discussed. The literature review on the body pain experience of workers and its impact on worker's safety and productivity are presented in section 7. Finally, in section 8 of this chapter, the literature review on the safety culture and safety climate is presented. All these sections of the literature review are further expanded one by one in the next sections.

2.2 The Construction Industry:

The construction industry is not only contributing to the social and economic development of countries but is also a major industry around the world which provides jobs to the millions of peoples and contributes to countries and world economy. This fact has been confirmed in different studies, including Beven (2010), Umar and Egbu (2018). The construction industry is further reported for a major portion of gross domestic product (GDP) in different countries, for instance, 6.10% in the United Kingdom, 5.50% in Japan and 9.0% in Oman (ONS, 2017; SHJ, 2017; NCSI, 2017-a). In the European Union (EU) member countries, the construction sector provides jobs to approximately 18 million peoples and contributes up to 9% of the total EU's GDP (EUCS, 2016). Overall, the construction industry employing 7% of the total world's workforce and accumulate 13% of the global GDP (Deloitte, 2017). In the United Kingdom, there are 296,096 construction firms that employed approximately 2,731,370 people giving a firm to employment ratio of 1:11 (Statista, 2018-a). The world population review shows the UK population in 2018 as 66,723,105. Thus the percentage of construction workers in the UK becomes 4% of the total population. It is expected that the construction industry will more than double in size (of 2010) by 2020, representing an estimated growth rate of 110% which will lead this industry to become a $7 trillion market, representing an overall proportion of 17.2% of the GDP in 2020 (Beven, 2010). Similarly, another forecast indicates that the global construction industry will reach 14 trillion US$ in 2025 which was 9.5 trillion US$ in 2014, reflecting a 67% growth as shown in figure 2.1 (Statista, 2017). Although both of these forecasts estimate a different value of the growth, however, what is clearly evident that the construction industry is rapidly growing. In the Australian construction industry, the employment rose from 1.0 Million people to 1.10 Million during one year's time from November 2016 to November 2017, resulting in an employment increase rate of 8.5% (Parliament of Australia, 2018). During the same period, the percentage of employment in construction in Australia (out of the total employment) rose from 8.9% to 9.4% (figure 2.2). The total population in Australia by the end of 2017 was 24.6 Million, thus the percentage of the population employed in construction become 5% (ABS, 2018). The growth in the construction industry is further expected to be growing as this industry will be utilized to address some of the key challenges which the human are facing on the earth. A report published by the World Resources Institute shows that approximately 1.20 billion people in urban areas around the world do not have access to affordable housing. The report further indicates that this number will rise by 30% by 2025, reaching 1.60 billion people who will not have access to affordable housing (WRI, 2017). Similarly, the World Health Organization report published in 2017 shows that 2.10 billion people have no access to clean and reliable water. The people who do not have access to clean sanitation, stand at 4.50 billion (WHO, 2017-a). The challenges clearly indicate that the expansion of the construction industry will be compulsory considering the future human requirements.

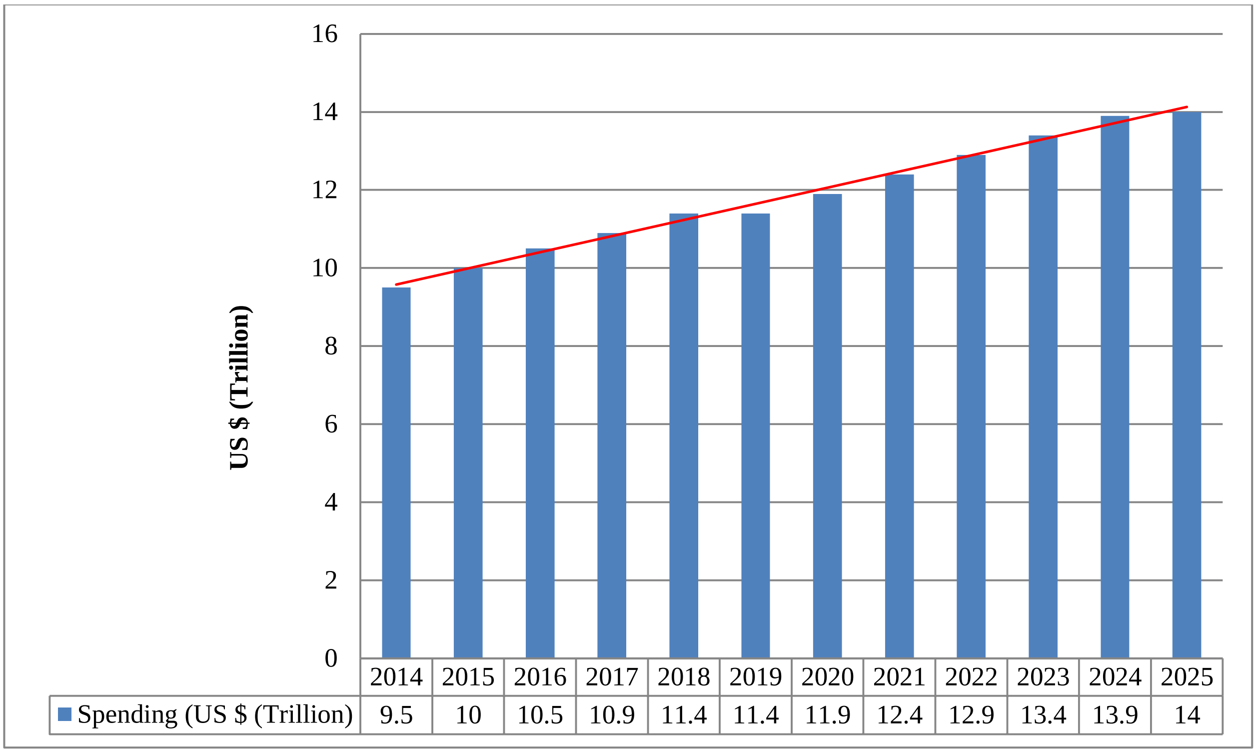


Figure 2. 1: Global Construction Industry Growth (Statista, 2017).

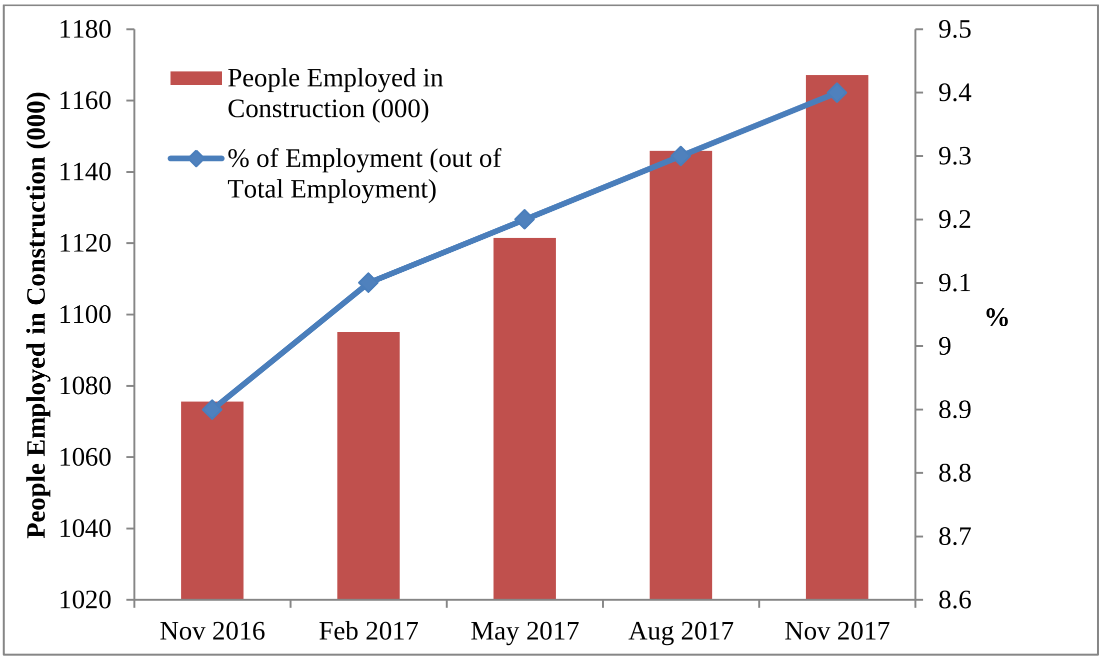


Figure 2. 2: Employment in the Australian Construction Industry.

In September 2018, the construction employment in the United States of America (USA) was 7,286,000 representing 2.23% of the total population. The USA Census Bureau data shows that a total of 1,329,452 Million US $ were spent on the construction only in the month of September of 2018 (Census Bureau, 2018). The value of the private construction spending was the highest which stood at 1,020,358 Million US $ as shown in table 2.1.

Table 2. 1: Value of Construction Work Done in September 2018 in the USA

Construction Sector	Sending (US$ Million)
Private (Residential)	556,424
Private (Nonresidential)	463,934
Public (State and Local)	288,112
Public (Federal)	20,982
Total	**1,329,452**

The above section provided a global snapshot of the construction industry; however, since the focus of this research is on the GCC region particularly in Oman, the next section explains the GCC construction industry with a specific reference to Oman.

2.2.1GCC's Construction Industry:

There are five member countries of the Gulf Cooperation Council (GCC), including Saudi Arabia, Oman, Qatar, Bahrain, and Kuwait. In this region, the economy is heavily reliant on oil and gas export which constitute more than 50% of its GDP (Umar, 2018). Despite the dip in oil prices in recent years and its effect on the GCC economy, investment in infrastructure projects continues. The value of the planned and ongoing construction project in all GCC countries in the year 2015 was 1,300 billion led by the United Arab Emirates, followed by Saudi Arabia as shown in figure 2.3 (Deloitte, 2015). A report published in Arabian Business (AB, 2017) in late 2017 indicates that there were 20,000 active construction projects worth US$ 2.4 trillion. According to Oman's budget report, the spending on development projects was estimated at US$ 3.12 billion (Omani Rials (OMR) 1.20 billion), representing the amount paid during the year 2017, as the actual work progresses (TOM, 2017). A comparison of the contract awarded in the GCC countries, in the first quarter of 2017 and 2018 shows an overall decline of US $ 5.0 Billion (Ventures, 2018). The construction contract awarded in the first three months of 2017 and 2018, in GCC countries is shown in figure 2.4. While there is an impact on the construction industry due to the economic situation, however different studies show that construction will be growing in the near future. A research conducted on the occupational safety and health regulations reported that the value of the construction industry in Oman will grow to 6.88 Billion Omani Rial, which was 2.26 Billion Omani Rial in 2016 (Umar et al., 2018). Moreover, the construction GDP in Oman is forecast to grow to 15.4% of the total GDP by 2026. Overall, they reported that the construction growth rate is forecasted to be at peak in 2020 (figure 2.5).

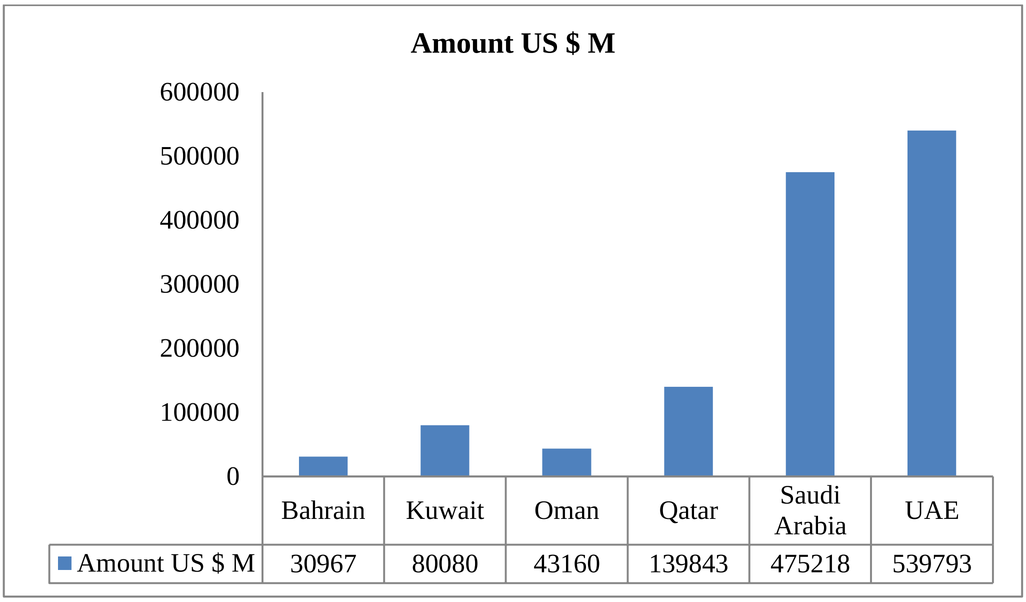


Figure 2. 3: Planned and Ongoing Construction Projects in Oman (Deloitte 2015)

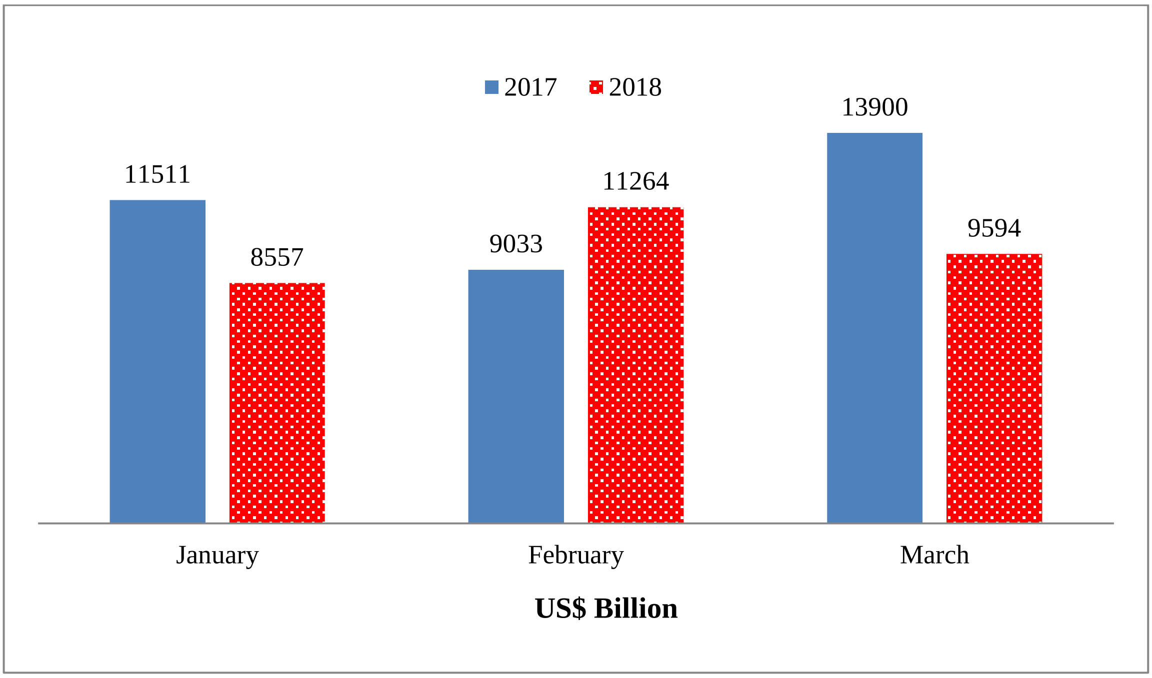
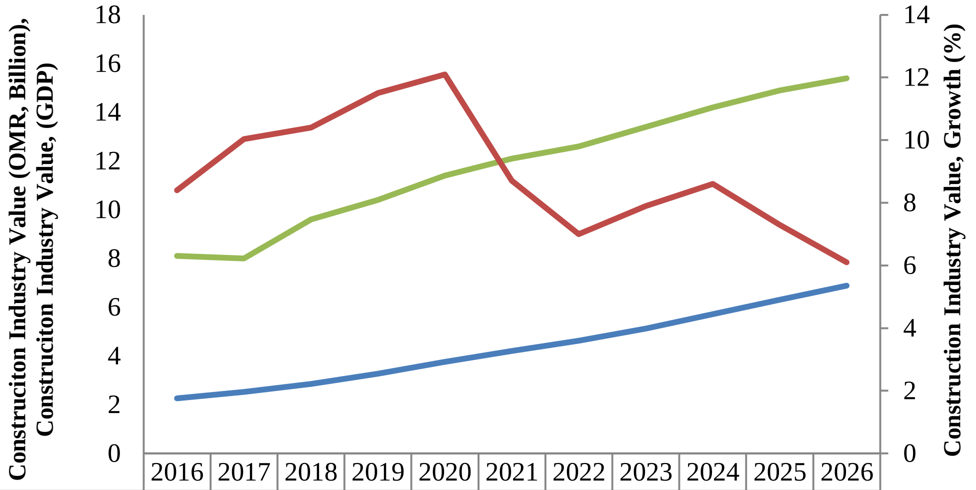


Figure 2. 4: Comparison of Awarded Construction Contracts In GCC (Ventures, 2018).



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Construction Industry Value, (OMR, Billion)	2.26	2.53	2.85	3.27	3.76	4.2	4.62	5.12	5.72	6.3	6.88
Construction Industry Value, (GDP)	8.1	8	9.6	10.4	11.4	12.1	12.6	13.4	14.2	14.9	15.4
Construction Industry Value, Growth (%)	8.4	10.03	10.4	11.5	12.1	8.7	7	7.9	8.6	7.3	6.1

Figure 2. 5: Oman Infrastructure and Construction Industry Forecasts (2016-2026).

All GCC countries are highly dependent on foreign workforce. Statistics published by the GCC Centre for Statistics show that the number of expatriate workers in different GCC countries was 13.86 million by the end of December 2017, which accounts for 69.3% of the total workforce in these countries (GCC Stat, 2018). The majority of these workers are from Asian and African countries. For example, workers from Bangladesh constitute the largest group of expatriate workers in Oman (NCSI, 2017-b). The total population of Oman in 2018 was 4,655,435 with an expatriate population of 2,047,788 making up 44% of the total Omani population (PC, 2018). In 2016, the construction workforce in Oman was approximately 725,000, of which 92% were foreign workers (Umar, 2016). The construction workforce thus, therefore, constitutes 16% of the total population of Oman. These calculations are the official data, which represent the workers who have a work permit/visa related to the construction profession. It is possible that the actual number of the workforce may be higher than this. To represent an insight of the GCC's construction workers, figure 2.6 is placed to shows the classifications of foreign workers in the construction industry in Oman (OSC, 2016). Similarly, table 2.2 shows the number of establishments by economic sectors and the workforce of these sectors including construction in the United Arab Emirates for the years 2018. Table 2.2 clearly shows that the construction industry is on the top of the list providing jobs to 1.70 million peoples with a total number of establishments of 65,419. If the construction sector of the United Arab Emirates is compared with the trade and repair services sector and the ratio of both the sector considering the number of establishments and the number of workforces, the construction sector has a ratio of 1:26 while the trade and repair sector has a ratio of 1:16. This clearly reflects that the construction sector provides more jobs which are almost double the jobs provided by the trade and repair sector per establishment (MHRE, 2018).

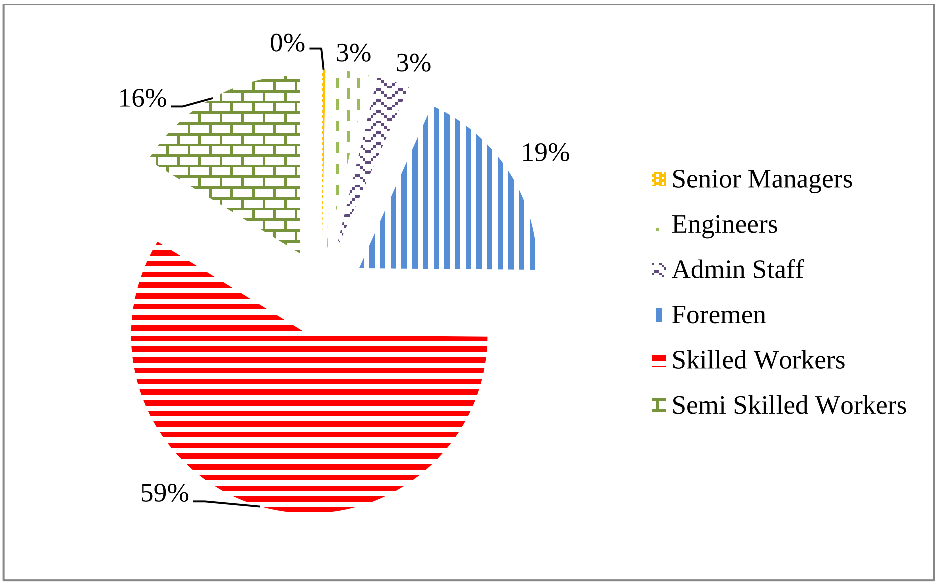


Figure 2. 6: Distribution of foreigner workers in construction organizations of Oman (OSC, 2016)

Table 2. 2: Number of Establishments and Workforce in Different Economic Sectors of U.AE (MHRE, 2018)

Sector	**Establishments (000)**	**Workers (000)**
Construction	65.419	1,702.502
Trade and Repair Services	128.633	1,107.119
Manufacturing	30.292	468.069
Real Estate and Rental and Business Services	30.702	608.139
Transportation Storage and Communication	24.145	355.713
Hotels and Restaurants	20.087	238.523
Community and Personal Services and Other	24.591	156.981
Educational Services and Studies	2.155	89.269
Financial Intermediation	2.45	72.846
Health and social work	3.394	86.284
Others	6.49	140.099
Total	**338.358**	**5,025.544**

Bahrain is another small country that is a member of the GCC and 765.3 square kilometers in size. According to the Gulf Research Center, Bahrain's total population was 1,501,116 in 2017. The number of expatriates stood at 823,610 representing 55% of the total population (GRC, 2018). The total number of workforce in the construction industry is 174,912 representing 12% of the total population of Bahrain (LMRA, 2018). The number of Bahraini national in the employed in the construction sector is the same as of Oman which stood at approximately 8% (12,235) of the total construction workforce (174,912) as shown in figure 2.7. Both the Omani and Bahraini construction industries employed more peoples as compared to the UK construction industry. More specifically the employment ratio in the Omani construction industry is 4 times more than the employment ratio of the UK construction industry. Similarly, the Bahrain construction industry employment is 3 times more than the UK construction industry.

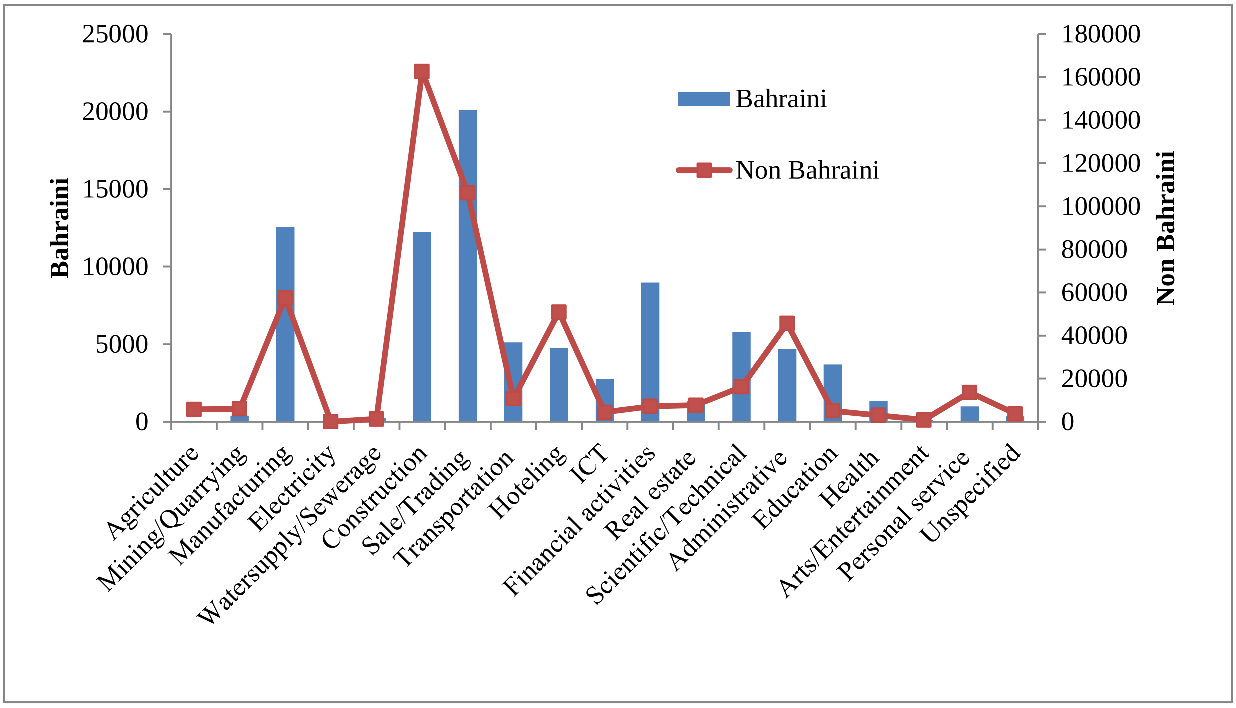
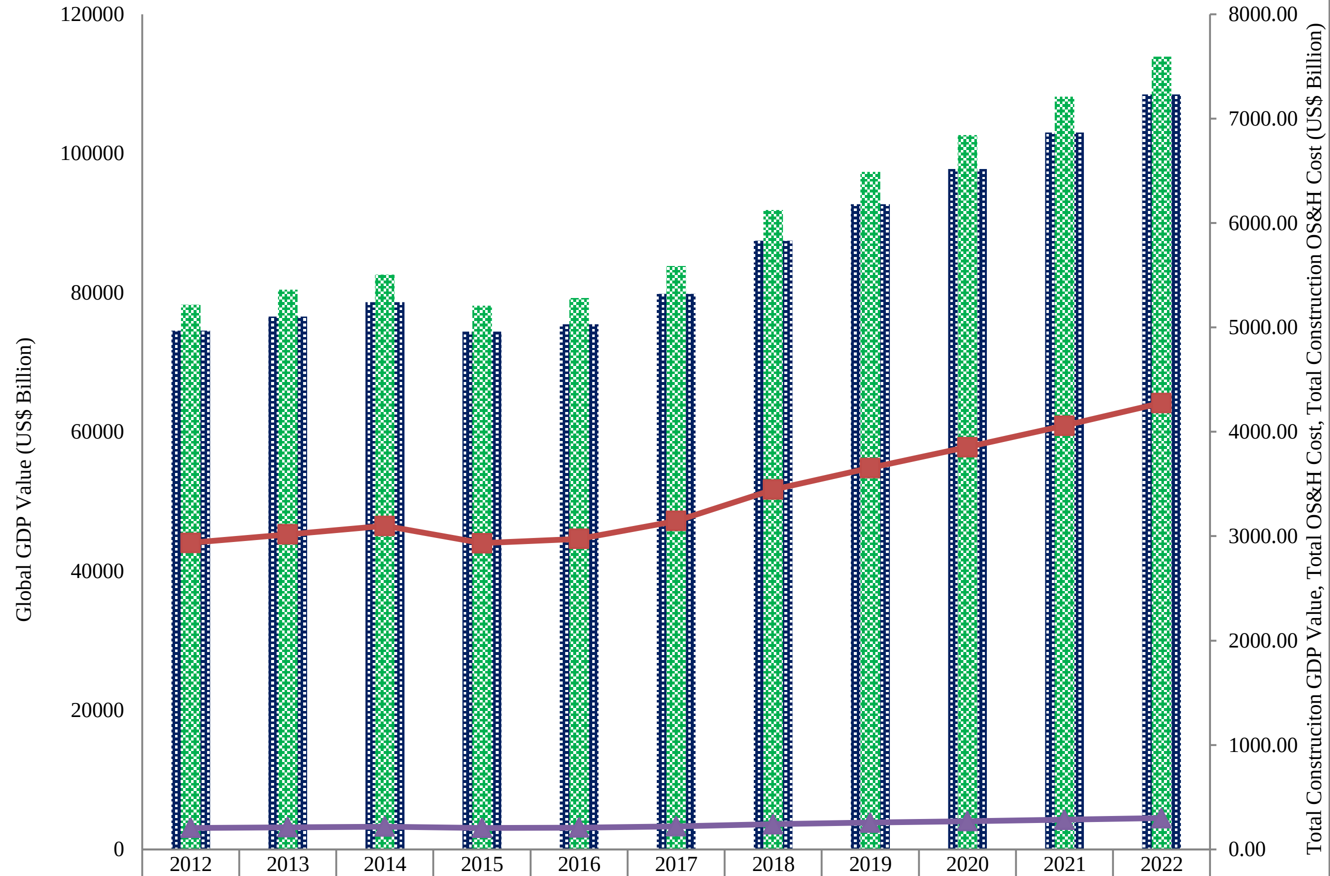


Figure 2. 7: Employment in Different Sectors of Bahrain (LMRA, 2018)

While the discussion in the above section clearly reveals that the construction industry in Oman and other GCC countries has significant importance in terms of employment and expected growth, there is a greater risk associated with the industry when it comes to safety and health issues. The next section, therefore, provides an overview of occupational safety and health in the construction industry both at global and GCC levels.

2.2.2 Construction Safety and Health:

The International Labour Organization (ILO, 2018) statistics show that approximately 2.78 million people die every year due to work-related accidents and diseases. This translates to 7616 deaths every day. The number of injuries and sickness stands at 374 million per year, which contributes towards individuals absent from work for many days (ILO, 2018). Although human life is priceless and cannot be translated into money, however, ILO estimates the annual economic cost of the poor occupational and health practice at 3.94% per year of the GDP (ILO, 2018). Statistics published by the Safe Work Australia show that from 2012 to 2013, work-related injury and disease cost the Australian economy a total of AUS$ 61.8 billion, representing 4.1% of Australian GDP (SWA, 2018). The forecast value of the world GDP for the year 2018 is 87,504.57 billion US $, thus the cost of poor occupational safety and health at a rate of 3.94% will be 3447.68 billion US $ per year (Statista, 2018-a). This is a huge cost, which is 20 times greater than the amount required to end the extreme poverty from the world which was calculated by Sachs (2015) at a rate of \$175 billion per year. It is expected that the world GDP will rise to the US \$108,523.32 billion in 2022, which was US\$ 74,535.41 billion in 2012, reflecting a growth rate of 46% in these ten years (2012-2022). This shows that a total amount of US\$ 37,396.71 billion will be spent on matters arises from poor occupational safety and health conditions (Statista, 2018-b). Although, the cost of poor occupational safety and health practices as shown in figure 1.1, cannot be brought to zero, however they can be minimized. If the cost of poor occupational safety and health practices is reduced by the half which currently stands at 3.94% of the global GDP, the expected saving in the coming three years (2020-2022) will be US\$ 6094.04 billion. Similarly, the global construction industry which currently accumulates approximately 7% of the total global GDP, and if the same percentage is considered, then total construction GDP value will reach US\$ 7596.63 billion by 2022 (Deloitte, 2017). If the cost of occupational safety and health in construction is considered to be the same as other industries (~3.94%), which apparently is expected to be more, the cost of occupational safety and health in construction will reach US\$ 299.31 billion by 2022 (figure 2.8). The saving in the occupational safety and health cost, by bringing the cost percentage which is ~ 3.94% to half of the current value (~1.97%), will be US\$ 291.58 billion in the three years from 2020-2022. While estimating the cost of occupational safety and health, it is necessary to keep in mind that some accidents which result in disabilities and deaths cannot be translated into financial losses accurately. The suffering of individuals with disabilities can only be best understood by the individual themselves or their families. Such suffering only ends when the lives of the affected individuals end. Similarly, the suffering of the dead individual’s families can only be understood by the concerned families. A translation of their suffering into financial loses would not be possible. Thus it is important to consider that occupational safety and health are not only related to the cost but a significant factor that apparently has a greater impact on the individuals and society.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Global GDP Value (US$ Billion)	74535.41	76596.14	78663.17	74429.03	75485.01	79865.48	87504.57	92734.03	97789.46	103029.66	108523.32
Total Construction GDP Value (US$ Billion)	5217.48	5361.73	5506.42	5210.03	5283.95	5590.58	6125.32	6491.38	6845.26	7212.08	7596.63
Total OS&H Cost (US$ Billion)	2936.70	3017.89	3099.33	2932.50	2974.11	3146.70	3447.68	3653.72	3852.90	4059.37	4275.82
Total Construction OS&H Cost (US$ Billion)	205.57	211.25	216.95	205.28	208.19	220.27	241.34	255.76	269.70	284.16	299.31

Figure 2. 8: Global GDP and Cost of Poor Occupational Safety and Health Practices (Deloitte, 2017)

The construction industry is regarded as one of the most hazardous industries. The International Labour Organization data for the year 2015 reveals that every year, more than 100,000 workers die on construction sites due to different occupational safety and health (OS&H) conditions. This means that the number of deaths on construction sites is roughly equal to 274 deaths per day. This number is nearly 30% of all occupational deadly injuries. Different statistical data reveal that construction labourers in different developed countries are three to four times more likely to die from accidents on-site compared to workers in other industrial sectors. In the developing world, there is a higher risk (three to six times more) of death linked with construction work than in developed countries (ILO, 2015). Many construction workers suffer and die from work-related illness developed from the prior influence of dangerous materials, such as asbestos and other chemicals. The construction industry remained on the top in most countries, in terms of worker's deaths as compared to other industries. For instance, statistics reveal that the construction industry in the United States involved the highest number of worker's death in 2016, accounting for 991 deaths. This further reflects an increase of 6% in fatalities when compared to 2016 data (BLS, 2018). This number (991) of worker's death in construction further represents 20% of the entire worker's death in the United States. As shown in figure 2.9, the number of fatalities reduced by 25% compared to 2006 data, which was 1,239 in 2006, the current number of fatalities (991) is still alarming. Fall from height was one of the main reasons for these fatal accidents and accounted for 384 (39%) of the total fatal accidents (991).

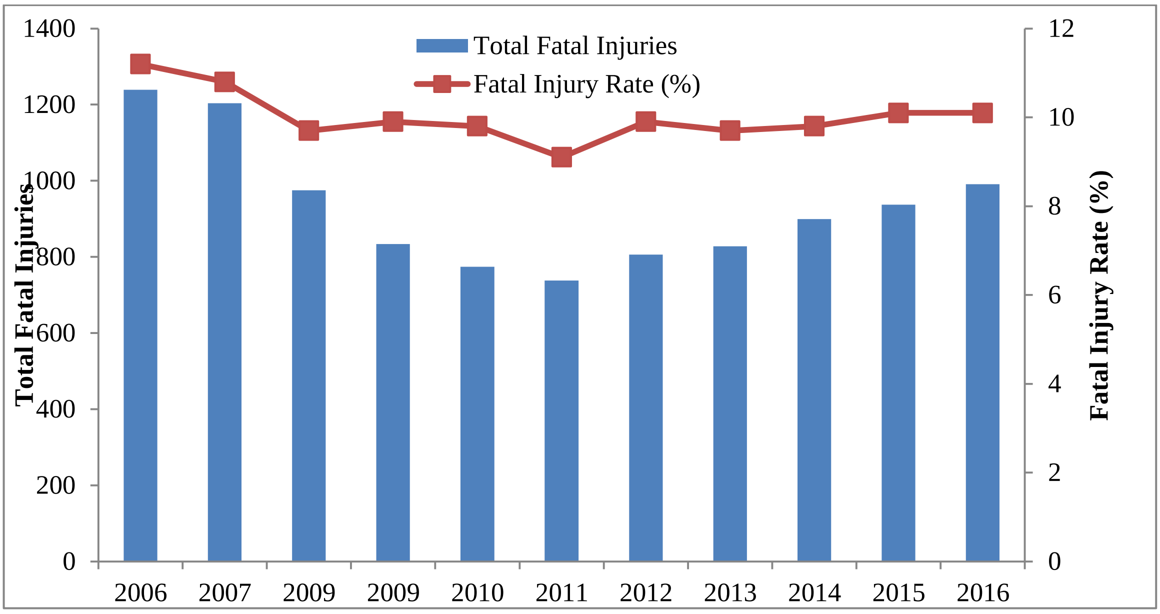


Figure 2. 9: Construction Worker Fatalities and Fatal Injury Rate in USA-2016 Data (BLS, 2018).

The statistics for 2017-2018 published by the Health and Safety Executive (HSE, 2018) in the United Kingdom show that there were 144 fatal injuries to workers in the past one year out of which 38 were from the construction as shown in figure 2.10. There was a further 100 death of the public in the same period of one year (2017-2018). The main reason for fatal accidents in the UK is the same as in the USA, which was due to falls from height, accounting for 35 (24.3%) of the total fatal accidents (HSE, 2018). The comparison of fatalities which was 233 between 2007-2008 and 144 for the year 2017-2018 shows that the fatality rate decreased by 62%. The safety performance in the United Kingdom is, therefore, comparatively better than the United States as the reduction in fatalities was only 25% in the United States. Although this is a simple comparison which takes into account only the reduction in the number of fatalities, therefore for a more valid comparison, other parameters would need to be considered as well. Such comparisons always help organizations and individuals to learn from each other experience and to improve the safety performance in their respective jurisdictions.

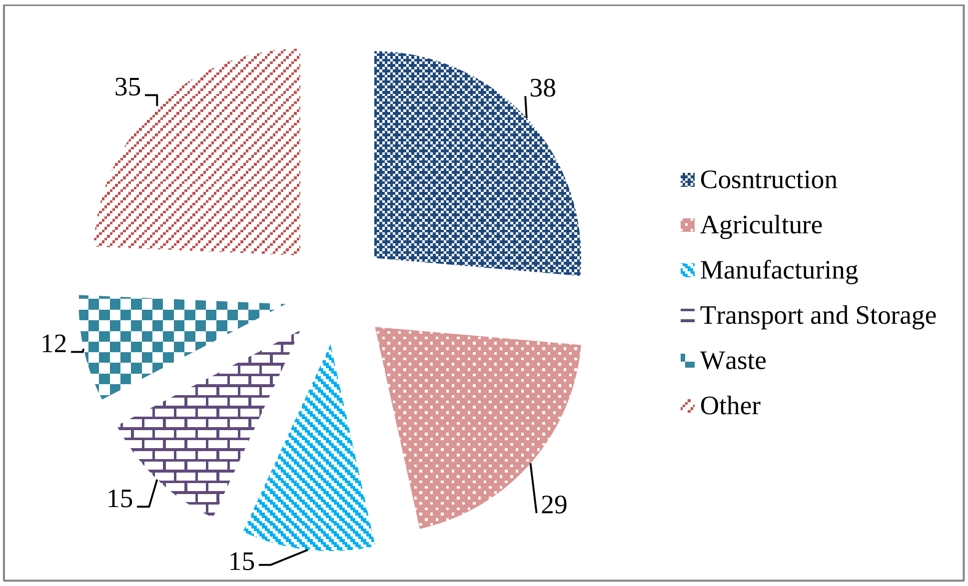


Figure 2. 10: Occupational Fatal Injuries in UK 2017-2018 (HSE, 2018)

In 2016 Australia reported that there have been 182 fatalities in 2016 representing a rate of death of 1.5 per 100,000 workers (SWA, 2018). The number of fatalities and fatalities rate, both have been reduced in Australia since 2006, which was 284 and 2.8 respectively as shown in figure 2.11. The reduction in the number of fatalities for the years 2006 to 2016 is recorded as 56%. The data further reveal that there were 35 fatalities among the workers working in the construction industry of Australia in 2016, representing 19% of the total fatalities. Figure 2.11 further shows the distribution of fatalities took placed in 2016 among different Australian industries which clearly reflect that the construction industry falls in the top three industries which have high fatalities (figure 2.12). Overall these three industries Transport, postal and warehousing; Agriculture, forestry and fishing; and Construction and accounted for 69% of the total fatalities in Australia and therefore are regarded as the most hazardious industries. The most common and frequent causes of fatality in the construction industry of Australia were the same as of the United Kingdom and the United States, which was ‘fall from height’ and was accounted for 27% of all the fatalities in construction in Australia. This percentage of fatalities in construction is based on the data spanning over the past ten years considering 2007 to 2016.

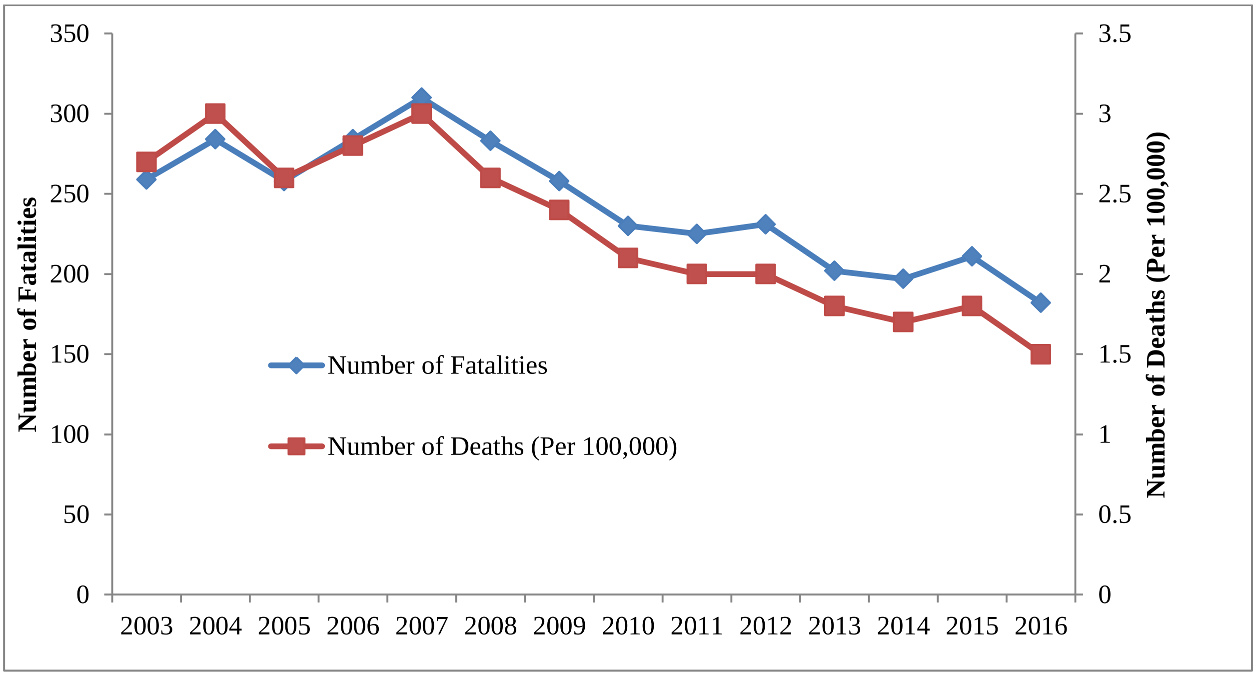


Figure 2. 11: Number of fatalities and fatality rate in Australia (2003 – 2016) - (SWA, 2018)

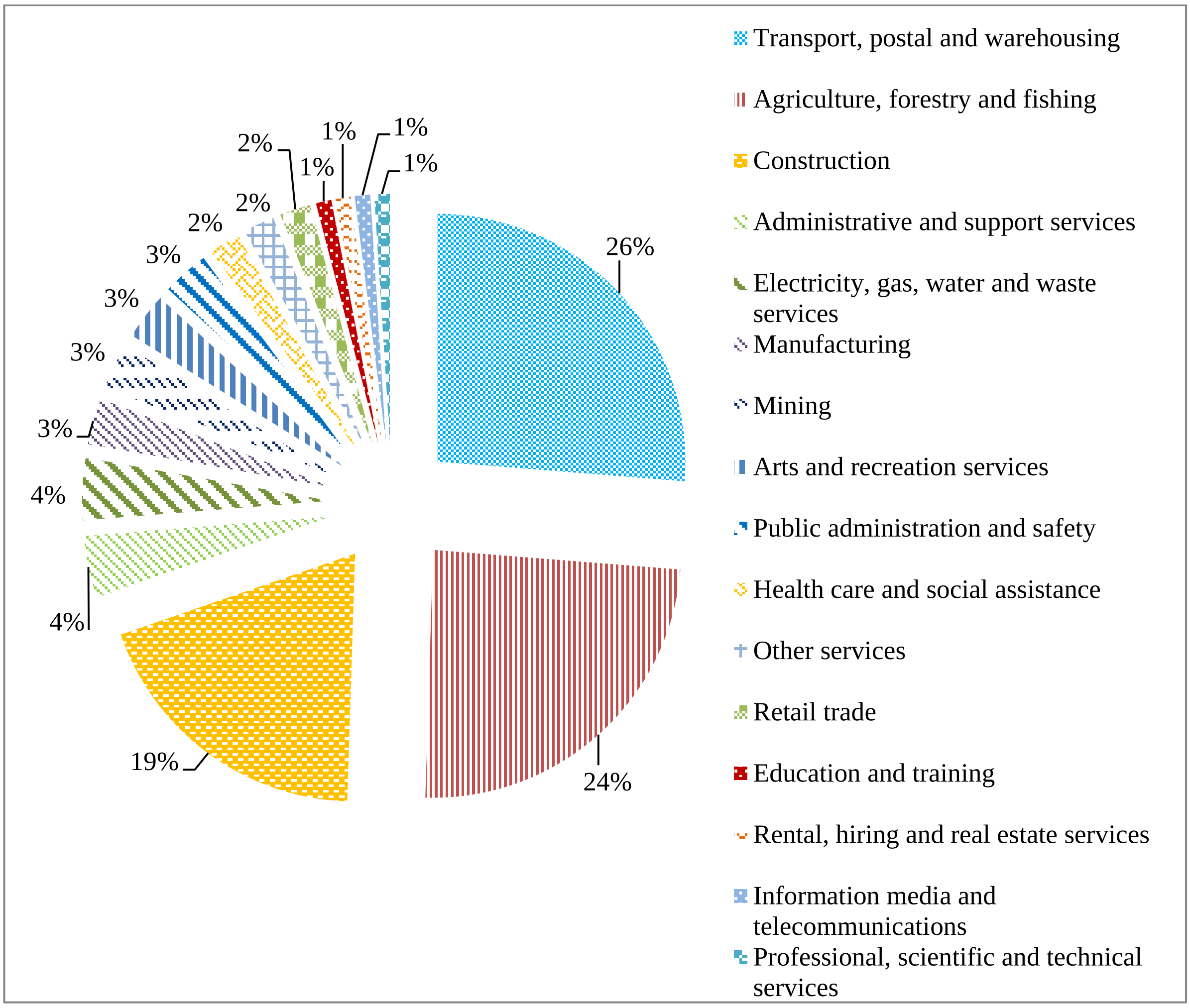


Figure 2. 12: Distributions of Fatalities in Australian Industries (SWA, 2018)

The next section describes the occupational safety and health in GCC countries with a specific reference to Oman.

2.2.3 Construction Safety and Health in GCC Countries:

Although no industry including construction is accident-free, so far around the world, the conditions in GCC countries, particularly in construction, are alarming. There is a lack of accurate data related to the number of accidents and fatalities in these countries except the report published in the media or international independent organizations. In recent days, the death of construction workers working the in construction of a stadium for football world cup 2022 has attracted the attention of a large number of media and international organizations. Some of these reports show the number of construction workers died at this project has already reached 1200, and further estimates that this number will reach 4,000 by the end of 2020 when this project will be completed (safety Media, 2018; ITUC, 2014). The Human Rights Watch report indicates that the total workforce in Qatar is approximately two million. 95% of this workforce are expatriates out of which 800,000 (=40%) are employed in the construction sector (Human Rights Watch, 2018). The report further shows that only in 2012, a total of 520 workers from India, Bangladesh, and Nepal died due to different work-related accidents and conditions in Qatar.

Similarly, Umar and Wamuziri (2016) noted that, officially, there are no statistics in Oman as to how many construction workers are injured at work. However, data from ten reputable construction organizations show that in 2014, more than 3500 construction workers received medical treatment due to work injuries. Due to the severity of injuries, around 10% of these workers were hospitalized. The report further reveals that roughly 18% of these workers, who were hospitalized, later died at their work or in hospital. In comparison to the previous year's data, the number of injured workers rose by 246. For various reasons including reputation, company owners hesitate to publicize such information. Umar and Wamuziri (2016) further quoted the analysis of one daily newspaper reports covering six months (from May 2015 to November 2015) and stated that in different accidents 9 construction workers died and 25 were injured in Oman were reported in this newspaper. Apparently, these were accidents taken place in major cities of Oman, therefore, were reported in the newspapers, there may be accidents resulting in injuries and fatalities in a remote area but may not be reported in the newspapers. Thus the actual number of fatalities and injuries may be greater than the one reported in the newspapers.

In the United Arab Emirates, almost 70% of construction organizations have a serious lack of understanding of the importance of safety and health and Safety policy. Construction organizations classified as a medium organization in size, have no specialized safety and health officer. Most of the small construction organizations and some of the medium-sized construction organizations do not have a written safety and health policy. Only 18% of construction organizations conduct continuous safety and health training with their workers (Middle East Annual Conference, 2014). Statistics related to occupational safety and health performance of construction organizations working in Dubai shows that in 2013, 71% of the construction companies (out of 130) have no occupational safety and health training for their workers. Similarly, more than 70% of the construction workers believe that the training they receive is outdated (safety Media, 2018).

The statistics published by the General Organization for Social Insurance (GOSI) of Saudi Arabia indicate that in the third quarter of 2018, occupational injuries in construction were

47% of the total occupational injuries in Saudi Arabia as shown in figure 2.13 (GOSI, 2018). This graph clearly shows that the construction industry in Saudi Arabia is the most harzardious sector which almost accumulates half of the injuries (3,625 out of 7,776) that took place in the third quarter of 2018. If the injuries number is estimated at the same rate as of the third quarter of 2018, then the total number of injuries will, therefore, stood at 14,500 (3625 x 4). The statistics further reveal that in the same period, fall from height was the most frequent cause of injuries followed by struck and collision, then rubbed and abrasion (figure 2.14). The General Organization for Social Insurance reports further indicates that the number of death in the third quarter of 2018 from the total injuries (7,776) was 16. This can be translated into the number of death per year which would be roughly equal to 64 (16x4). This number, however, appears not to be reliable simply because of the overall safety and health condition in the whole region. For instance, one project, the football world cup stadium, in Qatar resulted in 1,200 deaths from 2010 to 2017, roughly 171 deaths per year. It is hard to believe that worker's deaths per year in the UK (~144) are more than the deaths of workers in Saudi Arabia (~64). Similarly, in the United States, there are robust occupational safety and health systems are placed and implemented through the government organization Occupational Safety and Health Administration (OSHA), bust despite these systems there were 991 fatalities (10.10% of the total injuries) in the United States in 2016; much more than the fatalities of Saudi Arabia (~64 or 0.2% of the total injuries). The General Organization for Social Insurance, Saudi Arabia statistics of the third quarter of 2018 further shows that 4,002 injuries (51%) out of 7,776 were recovered without disabilities, while 386 injuries (5%) resulted in permanent disabilities. The report further indicates that 3372 injuries (43%) are still under treatment as shown in table 2.3.

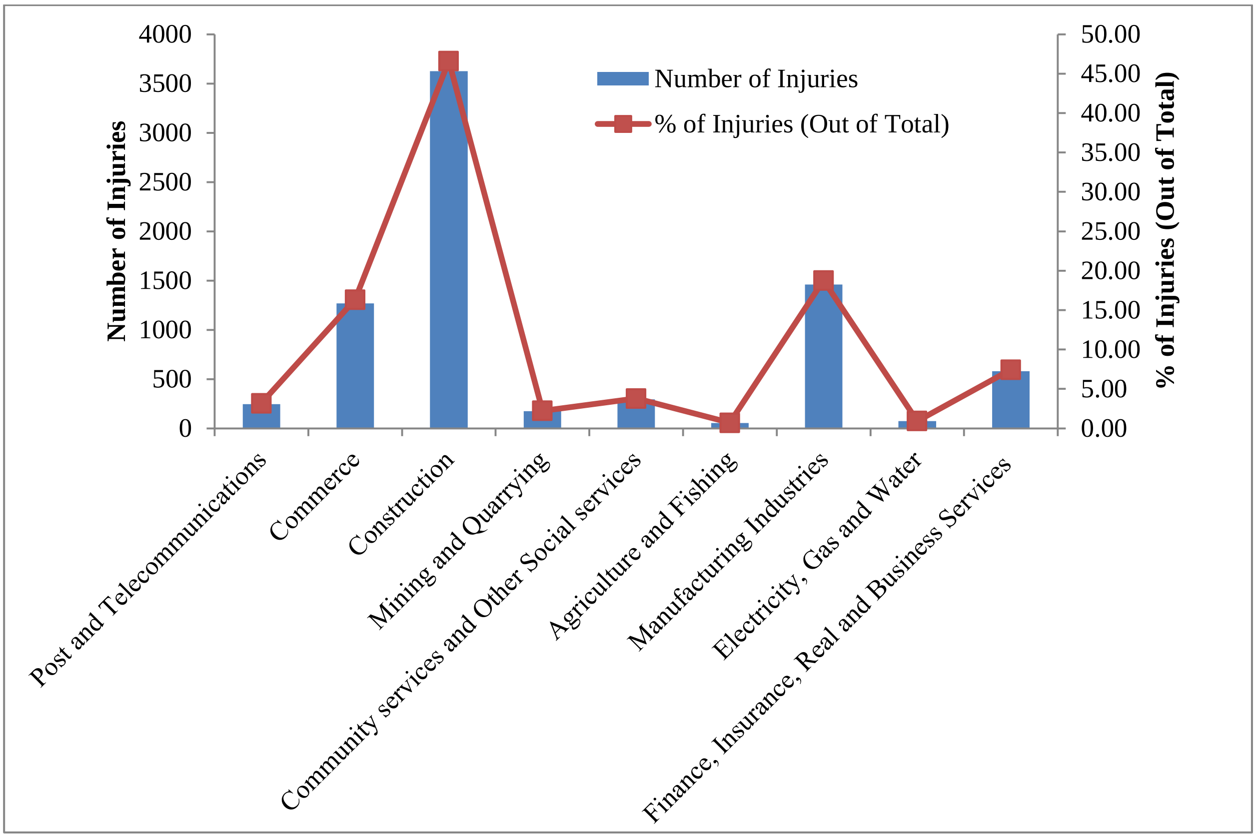


Figure 2. 13: Number and Percentage of Injuries in Different Sectors in Saudi Arabia – 3rd Quarter 2018 (GOSI, 2018).

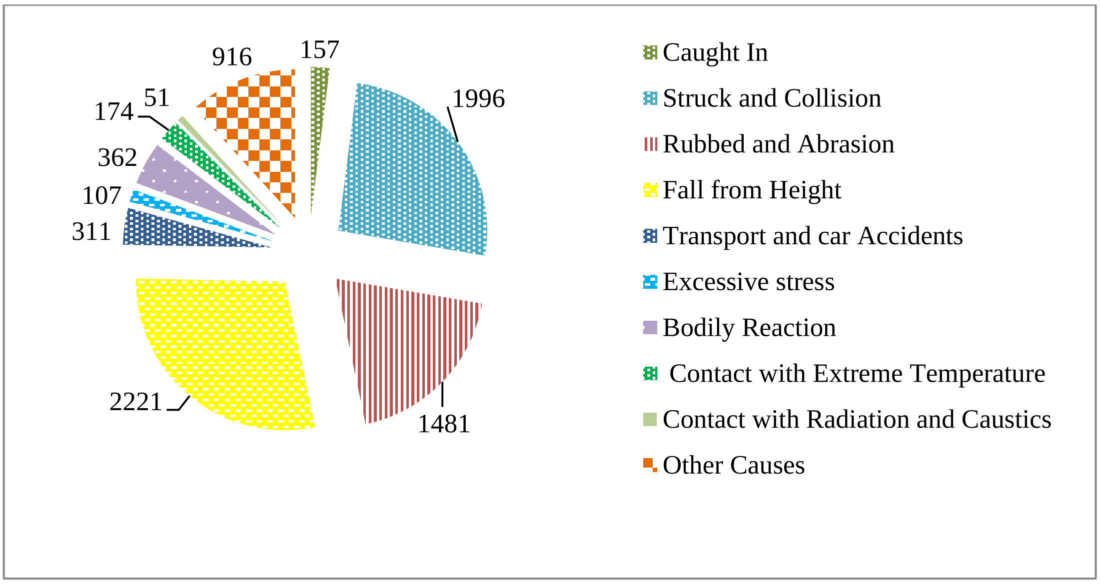


Figure 2. 14: Different Causes of Injuries in Saudi Arabia – 3rd Quarter 2018 (GOSI, 2018).

Table 2. 3: Number of Injuries and Recovery Status in the Industrial Sector of Saudi Arabia – 3rd Quarter 2018 (GOSI, 2018)

During the Third Quarter 2018	Injuries distribution in the private sector by recovery situation			
Office name	**Cured Without Disability**	**Cured With Disability**	**Death**	**Under recovery**
Riyadh Office	864	182	7	612
Al Qassem Office	47	9	1	116
Hail Office	6	0	1	17
Al Kharj Office	0	1	0	26
Makkah/Jeddah Office	793	59	1	657
Makkah Office	319	24	3	137
Madinah Office	199	35	0	332
Tabouk Office	28	2	0	43
Al Taif Office	60	2	0	57
Yanbu Office	29	11	0	45
Eastren Region Office	1 181	23	2	504
Ahsa Office	197	7	1	188
Al Jouf Office	0	0	0	1
Jubail Office	228	17	0	127
Hafer Al-Batin Office	0	0	0	8
Northren Borders Office	1	3	0	2
Assir Office	29	4	0	305
Jazan Office	2	1	0	140
Al Baha Office	6	0	0	24
Najran Office	12	4	0	20
Bisha Office	1	2	0	11
Total	**4,002**	**386**	**16**	**3,372**

Many researchers have concluded that construction in Kuwait is the most hazardous industry (Kartam and Bouz, 1998; Al-Tabtabai, 2002; Al-Kandary and Al-Waheeb, 2015). Construction accidents in Kuwait were accounted for 34% - 48% for all injuries involving disabilities from 1994 to 1996. Similarly, in the same period, the accidents in the construction industry in Kuwait were accounted for the deaths of 42% - 62% resulting from all injuries (Al-Kandary and Al-Waheeb, 2015).

The above facts and discussion clearly reveal that the occupational safety and health conditions around the world are not at a satisfactory level. Workers in developing countries are more open to the risks of having accidents at work compared to developed countries. The construction industry is considered is a leading industry that provides work to a large number of people globally. At the same time construction work is one of the most harzardious works where workers are more open to accidents. The construction industry is further revealed to be expanding in the future. The GCC construction industry is also expected to be growing and will employ more people in the future. Overall, in different GCC countries, the occupational safety and health conditions in construction are worse compared to mature construction industries of some advanced countries. The improvement of occupational safety and health conditions in all industrial sectors are in the best interest of the individuals, organizations, societies, and countries.

As different statistics presented in the above section show that occupational safety and health in the GCC region including in Oman is not at a satisfactory level, the big question is then how it can be brought to the satisfactory or desired level. Similarly, the safety performance in the GCC construction industry is poor when compared with the countries that display improved safety performance. Poor safety performance means that there are more accidents and fatalities. The next section, therefore, describes the main causes of accidents in construction from the published literature. This review is important as this helped to focus on the elements for the development of the tracing model for the causes of accidents in construction in Oman.

2.3 Causes of Accidents:

Causes of accidents in construction remained an attractive topic for researchers in construction management. This may be due to the fact that this area may have a significant impact on the reduction of accidents in similar construction projects if the management develops strategies on how to avoid such accidents in their future projects. To develop a strategy to avoid the accidents in a construction project it is, therefore, necessary first to know the existing causes of accidents. As discussed in the above sections, construction is a major industry in the United States, however, when it comes to accidents, construction is also accounted for 20.77% of the total fatalities (971/4674). The statistics published by the Occupational Safety and Health Administration (OSHA) further show that four different causes were accounted for 582 workers' deaths, roughly equal to 60% of the total fatalities in construction in 2017 (OSHA, 2017). These four causes were;

- Falls from height [381/971; 39.23%]
- Struck by Object [80/971; 8.23%]
- Electrocutions [71/971 (7.31%]
- Caught-in or between [50/971; 5.14%]

The 2018 statistics published by the Health and Safety Executive (HSE) in the United Kingdom reveal that there were a total of 141 workers were killed at the workplace during the past year. Construction was accounted for a total of 38 deaths (38/141; 26.95%). The "falls from a height" was one of the main causes of these fatalities in the UK which was accounted for 38 workers (26.95%) deaths (HSE, 2018). Other causes of fatal accidents were;

- Falls from height [38/141 = 26.95%]
- Struck by moving vehicle [26/141 = 18.43%]
- Struck by moving object [23/141 = 16.31%]
- Trapped by something collapsing/ overturning [16/141 = 11.34%]
- Contact with moving machinery [13/141 = 9.21%]

Similarly, construction in Australia is regarded as a major industry not only because of the current employment which stood at 9% of the total employment in Australia but also due to the future economic and employment growth as shown in figure 2.15 (SWA, 2018). Construction in Australia, however, is also regarded as third-highest number in fatalities and stood at 6th highest fatality rate [three workers deaths out of 100,000] in Australia. The main causes of the fatal accidents in construction in Australia were;

- Falls from height = 28% [112 deaths]
- Vehicle collision = 16% [65 deaths]
- Electrocution = 15% [61 deaths]
- Being hit by a moving object = 12% [48 deaths]
- Being hit by a falling object = 11% [46 deaths]
- Being trapped between or in equipment = 8% [31 deaths]
- Other causes = 9% [38 deaths]

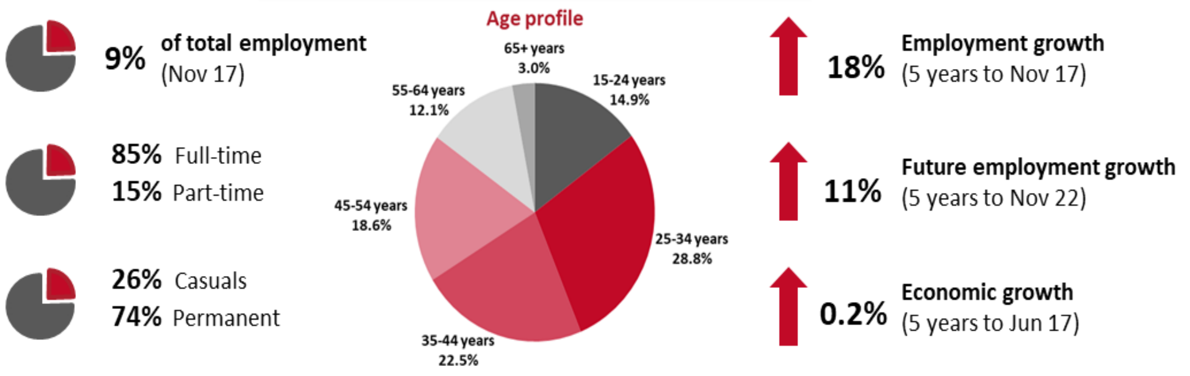


Figure 2. 15: Australian Construction: Priority industry snapshots (2018).

The role of Organizations such as OSHA (USA), HSE (UK) and Safe Work (Australia) with deals with safety and health becomes very important to drive the safety and health performance of a particular country. These organizations become the main source of safety and health data to reflect the safety performance of the industry. When it comes to the Gulf Cooperation Council (GCC) member countries, there is a lack of such organizations. In case these organizations exist, they are not fully functioning or not working effectively. This is one of the main challenges in this region which was truly highlighted by Umar and Wamuziri (2016). They further discussed how this challenge can be transferred to the opportunity by establishing an independent safety and health organization at the country level. Clearly, if the causes of accidents in construction would be known at project, organization or country level, they can be used to develop strategies and guidelines on how to eliminate or reduce a specific cause of accidents in the future. Any strategy or guideline to eliminate or reduce the causes of accidents without knowing the causes itself will not be effective and could cause confusion among the stakeholders and organizations. For an effective strategy which can be helpful to reduce the number of accidents in construction, knowing the causes of accidents is not enough. For example, if there have been many accidents in a construction project which were caused by falls from height, does this information is good enough to develop a strategy to effectively reduce the number of accidents. The cause (falls from height) will need to be further investigated. For example, the 'falls from height' appears to be a common cause of accidents in construction, but what are the factors which contribute to this cause. Does there was negligence from the worker which cause an accident in the form of 'falls from height'? Who could be responsible for this negligence, the worker, the site supervisor or the top management? For instance, let say the worker is responsible for this negligence; the top management should not consider themselves as non-accountable in such a situation. It is important to know the reason for that negligence which causes the accident. Such causes of negligence may include work pressure, fatigue, work experience or poor visibility. Ultimately, this should be the prime responsibility of the top management to give appropriate training to the workers and empower them to not to accept the risk at work.

Construction management researchers have proposed several accident causation models and root causes. McClay's (1989) identified three key elements of accidents including; hazards, human actions, and functional limitations. Hinze's (1996) distraction theory argued that production pressures can distract workers from the hazards and increase the probability of accidents. Abdelhamid and Everett (2000) identified management deficiencies, training, and workers' attitude as the three general root causes. The "constraints-response" model by Suraji et al. (2001) argues that project conditions or management decisions can cause responses that create inappropriate conditions or actions that lead to accidents. Gibb A et al. (2006) identified worker, workplace, material, and equipment as shaping factors of accidents in construction. The accident root causes tracing model (ARCTM) presented by Abdelhamid and Everett (2000) discussed four main causes of accidents that are from;

a) Management actions / inactions;

b) Unsafe acts of worker or co-worker;

c) Non-human related events; and

d) An unsafe condition that is a natural part of initial construction site conditions.

The model proposed by Mitropoulos (Mitropoulos et al. 2005) identifies the need for two accident prevention strategies a) reliable production planning to reduce task unpredictability, and b) error management to increase the workers' ability to avoid, trap, and mitigate errors. A study on the causes of accidents in the construction industry in Uganda linked the major causes of accidents in construction to inadequate supervision, the use of incompetent personnel, and the use of inappropriate construction techniques (Lubega et al. 2000). The research concluded that accidents are caused by a wide range of factors including;

1. Lack of awareness of safety regulations;

2. Lack of enforcement of safety regulations;

3. Poor regard for safety by people involved in construction projects;

4. Engaging incompetent personnel;

5. Non-vibrant professionalism;

6. Mechanical failure of construction machinery/equipment;

7. Physical and emotional stress; and

8. Chemical impairment.

Research conducted by Hamid et al. (2008) in Malaysia on the causes of accidents on construction sites concludes that the main cause of construction accidents are workers' negligence, failure of workers to obey work procedures, work at high elevation, operating equipment without safety devices, poor site management, harsh work conditions, low knowledge and skill level of workers, failure to use personal protective equipment and poor workers attitude about safety. Haslam et al., (2005) in their studies of 100 individual construction accidents summarized the levels of involvement of key factors in the accidents as problems arising from workers or the work team (70% of accidents), workplace issues (49%), shortcomings with equipment-including PPE (56%), problems with suitability and condition of materials (27%), and deficiencies with risk management (84%). They further suggest that design and cultural factors shape the circumstances found in the workplace, giving rise to the acts and conditions which, in turn, lead to accidents. It is argued that attention to the originating influences will be necessary for sustained improvements in construction safety to be achieved.

Research on the causes and effects of accidents on construction sites conducted in Nigeria found that workers are the major contributors to the causes of accidents on construction sites, which ranges from 53% to 67% of the main causes of accidents in different sizes of the construction organization. Although there are further 25 different factors that contribute to accidents on construction sites, the research also concludes that workers are the most affected people from accidents whatever the cause (Kadiri et al., 2014). The study by Ali et al., (2010) reveals that accidents are generally caused by unsafe acts and unsafe conditions besides other sub-causes. Accidents can result from a combination of contributory causes. The main causes of construction accidents identified in their study are the human element, poor site management, failure to use personal protective equipment and unsafe equipment used in construction work. Considering the existing literature on the causes of accidents, it is clear that much of these causes were drawn from the literature or the data collected through the questionnaire. Apparently, the causes of accidents identified in the existing literature are complex in nature and could be difficult to be adopted by the industry. The main causes of the accidents in construction from the literature are;

- Equipment / Materials
- Worker
- Environment
- Management

The question is how to link an accident to these main causes. This research, therefore, attempts to develop a model that could be used to trace or map an accident to one of these main causes. The method adopted to achieve this aim is explained in the next chapter. When construction organizations will be able to find the main cause of accidents, they will be in a better situation to control such causes by developing different strategies and investing in safety. One of the main reasons which make the organizations reluctant to invest in the safety-related issue is that matters such as accidents arising from poor safety arrangement don't occur on a regular basis. Construction organizations however negating the fact the in most cases such matter results in a huge cost. The cost of accidents is therefore important and a true cost of accidents will motivate the construction organizations to invest in the safety-related issue. The next section, therefore, sheds light on the costs of accidents considering both direct and indirect costs.

2.4 Cost of Accidents:

One of the objectives of this research was to evaluate and compare the costs of accidents in GCC construction. The existing literature did not provide a compelling piece of work that establishes the costs of accidents in GCC construction. The literature review provided here, therefore, aims to consider the cost parameters that can be helpful in the evaluation of the costs of accidents in the GCC construction industry. For this purpose, the costs of accidents in some advanced countries such as the United States of America, the United Kingdom, Australia, and South Africa were considered. Accidents in construction include not only direct physical injury to persons or damage to property but also short and long term effects or incidents due to other exposures on sites that affect the workers' health and physical well-being. Costs associated with accidents in the construction industry can be categorized as direct and indirect costs. Direct costs tend to be those associated with the treatment of the injury and any unique compensation offered to workers as a consequence of being injured and are covered by workmen's compensation insurance premiums. Indirect costs include reduced productivity for both the returned worker(s) and the crew or workforce, clean-up costs, replacement costs, costs resulting from delays, supervision costs, costs related to rescheduling, transportation, and wages paid while the injured is idle (Hinze, 1994). The costs of accidents (direct and indirect) can be substantial. Research conducted in the UK showed that indirect costs are eleven times more than direct costs (MFI, 2003). The average cost of accidents in the USA, which is 6.5% of the total value of completed work and the UK, which is 8.5% of the tender value is used to establish the costs of accidents in the selected GCC countries (BRT, 1995; Anderson, 1997). Some of the recent studies reveal that the costs of accidents in construction in South Africa are 4.3% to 5.4% of the total project value (Shohet et al., 2018; Smallwood, 2004). Similarly, Everett and Frank (1996) noted that the costs of accidents in construction projects can be up to 15% of the cost of the construction. Similarly, Forteza noted that the costs of accidents in the USA construction industry range from 6.5% to 7.9% of the total cost of the construction project (Forteza et al., 2017). In another study conducted by Hallowell on the costs of accidents reported that the costs of accidents can be 15% of the total cost of a residential project (Hallowell, 2011). While looking into these costs of the accidents reported above, the average costs of accidents can be calculated at 8.63% of the cost of the construction project. It has been, however, observed that the costs of accidents reported by The Business Roundtable (BRT, 1995) and Anderson, (1997) have been acknowledged and widely used by the construction management researchers as compared to the other studies. In this research, the USA and UK values of the costs of accidents reported by The Business Roundtable (BRT, 1995) and Anderson, (1997) are therefore used.

Waehrer et al. (2007) considered that costs of work-related accidents that result in injuries and sickness can be classified into main three categories, a) direct costs, b) indirect costs, and c) quality of life cost. The cost components they included in the direct costs were;

- Payments for hospital
- Payment for the physician, and allied health services, rehabilitation, nursing home care, home health care, medical equipment, and burial costs
- Insurance administrative costs for medical claims

- Payments for mental health treatment, police, fire, emergency transport, coroner services, and property damage

Indirect costs were further classified into the following categories;

- Worker productivity losses which include wage losses and household production losses
- Administrative costs which include the cost of administering workers' compensation wage replacement programs and sick leave

The quality of life costs was referred to as the value attributed to the pain and suffering that workers and their families experience due to the accident which causes the injury or sickness.

A research study funded by the Center to Protect Workers' Right (CPWR) in the United States reported that the average cost of fatal or non-fatal injury arising from an accident in construction is US$ 27,000. This cost is almost double than the average cost of fatal or non-fatal injury in other industries which stood at US$ 15,000 (Waehrer et al., 2007). The statistics published by the National Institute of Occupational Safety and Health (NIOSH) in the United States indicate that the average cost of an accident that results in the death of a worker is US$ 867,000 (NIOSH, 2006). This cost, however, doesn't include the cost of quality of life losses. The average cost of a fatal accident in the construction industry of the United States estimated by Waehrer et al. (2007) stands at US$ 1.0 Million, which is comparatively more than the estimate made by the NIOSH. Overall, if the cost of the quality of life losses is also added with the average cost of a fatal accident in construction, then the total average cost will stand at US$ 4.0 Million. In other words, the cost of the quality of life losses resulted from a fatal accident in the United States construction is equal to US$ 3.0 Million. In terms of direct costs of non-fatal accidents in the United States construction industry, which required medical treatment, was estimated at $777. This, however, doesn't include the cost of work or productivity which stood at US$ 618. Thus the direct cost of non-fatal construction accidents required medical treatment with the cost of work or productivity can be estimated at US$ 1,395. Similarly, the direct cost of a fatal accident that requires medical treatment in the construction industry of United States costs around US$18,300 (Miller et al., 2002; Waehrer et al., 2007). This can be translated to an average direct cost of an accident, either fatal or non-fatal, which is equal to US$ 9,850.

Research conducted in the UK on cost and benefit analysis revealed that when total costs of accident prevention were compared to the total benefits of accident prevention, the benefits far outweigh the costs of accident prevention by a ratio of approximately 3.1, which means that when contractors, irrespective of their sizes, spend £1.00 on accident prevention, they gain £3.00 (Ikpe et al., 2012). The cost of accidents can be understood by contractors and represents a tangible measure that can be related to project financial accounts and both the income statement and balance sheet of a contractor (Tang et al., 2004; Booth and Panopoulos, 2005). The costs of an accident also affect the workers and society, as illustrated in Table 2.4. Thus, this category of cost is very often at the forefront of considerations of the costs of health and safety.

Table 2. 4: Costs of Accidents Incurred by Stakeholders (Ikpe et al., 2012)

Stakeholders	**Intangible Costs**	**Tangible Costs**
Worker	Pain and suffering, moral and psychological suffering (especially in the case of death and permanent disability)	Loss of salary, reduction of professional capacity, loss of time (medical treatment), site compliance of health, and safety issues
Family and friends of the affected worker	Moral and psychological suffering, medical and family burden	Financial loss, extra costs, loss of time to take care of the injured worker
Coworkers	Bad feeling, worry, or panic (in case of serious or frequent accidents)	Loss of time, increase of workload, and training of temporary staff
Employer	Bad reputation, litigation cost, insurance cost, and compensation cost	Decrease in production; damages to machinery, equipment, and material; quality losses; recruitment and training of new staff; increase of production costs; increase of insurance premium; administrative costs; litigation costs; and absenteeism
Society	Reduction of the human labor potential, and reduction of the quality of life	Loss of production, increase of social costs, medical treatment and rehabilitation costs, and decrease of standard of living

Top management of small construction organizations is considered to be reluctant to spend money on occupational safety and health. This is due to the fact that accidents normally don’t happen in construction projects on a regular or daily basis ((Agumba and Haupt, 2012; MacEachen et al., 2010). It is therefore essential that the top management should have an awareness of the costs of accidents in their projects. This will help them to change their perception and will make them prepare to spend on safety and health matters. Hinze (2006) noted that if the actual cost of accidents is well known to the management, they will be able to make an effective decision related to the safety and health in their organizations or projects. The true cost of accidents will enable top management to consider safety and health not only as a part of the worker's well-being but also from an economic perspective. The true cost of accidents would also be more attractive for the owner as there could be great economic benefits for them. In this regard, the relationship between costs of safety and health and its benefits was best projected by Ikpe et al. (2012) as shown in figure 2.17. This figure indicates that if the prevention costs reduce, the costs of accidents will increase. Similarly, if the cost of prevention will be more the benefits arising from the low number of the accident will more.

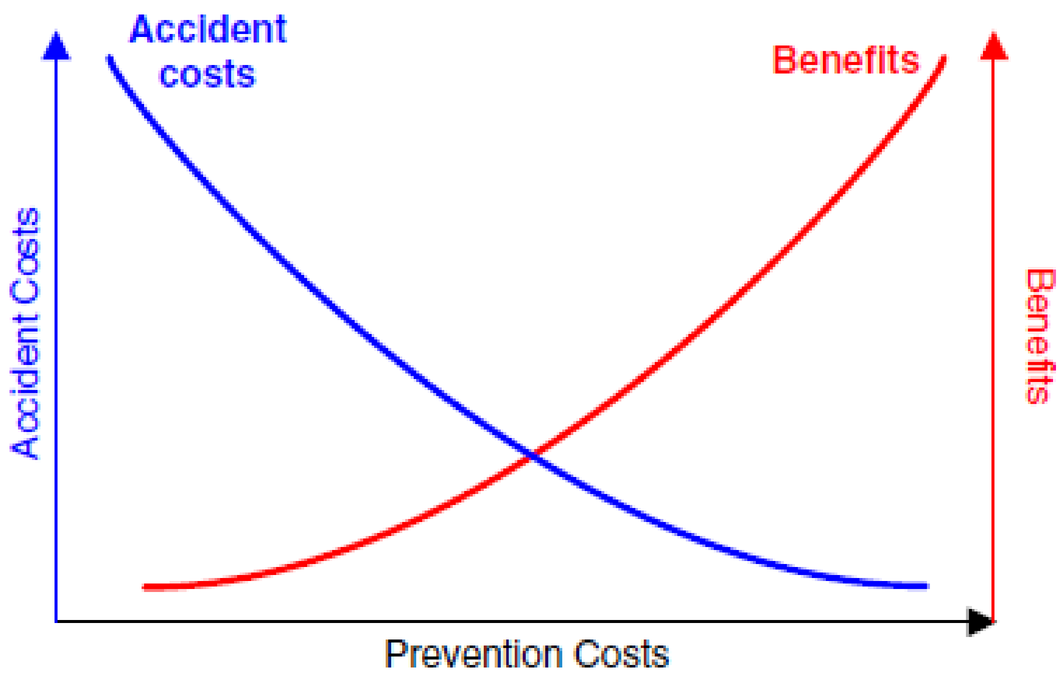


Figure 2. 16: Typical Relationship Between Accident Costs and Prevention Costs

A research study on the cost of accidents carried out in South Africa (SA) considering a total of 100 different types of accidents including 14 fatal accidents, estimated the total cost, including direct and indirect, of all these accidents at US$ 2.37 Million (Haupt and Pillay, 2016). The direct cost of all these accidents was estimated at US$ 0.726 Million, while the indirect cost of accidents stood at US$ 1.64 Million, double than the direct cost. This can be translated that one accident in South Africa either fatal or non-fatal cost around US$ 23,700. The direct cost of one accident in South Africa can be therefore US$ 7,260, while the indirect cost will be US$ 16,400. The breakup of fatal and non-fatal accidents used in this research is given in figures 2.18and 2.19. The cost of one accident either fatal or non-fatal estimated in the United States (~US$ 27,000) and in South Africa (~23,700) is considered to be comparable as the difference between both the estimates stands at 12.30%.

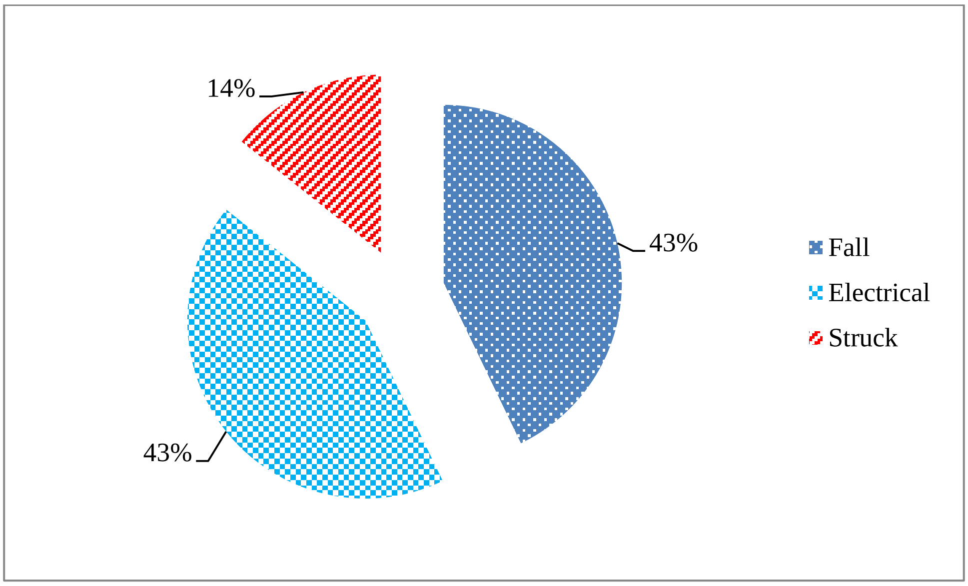


Figure 2. 17: Causes of Fatal Accidents in the Sample (6 out of 100)

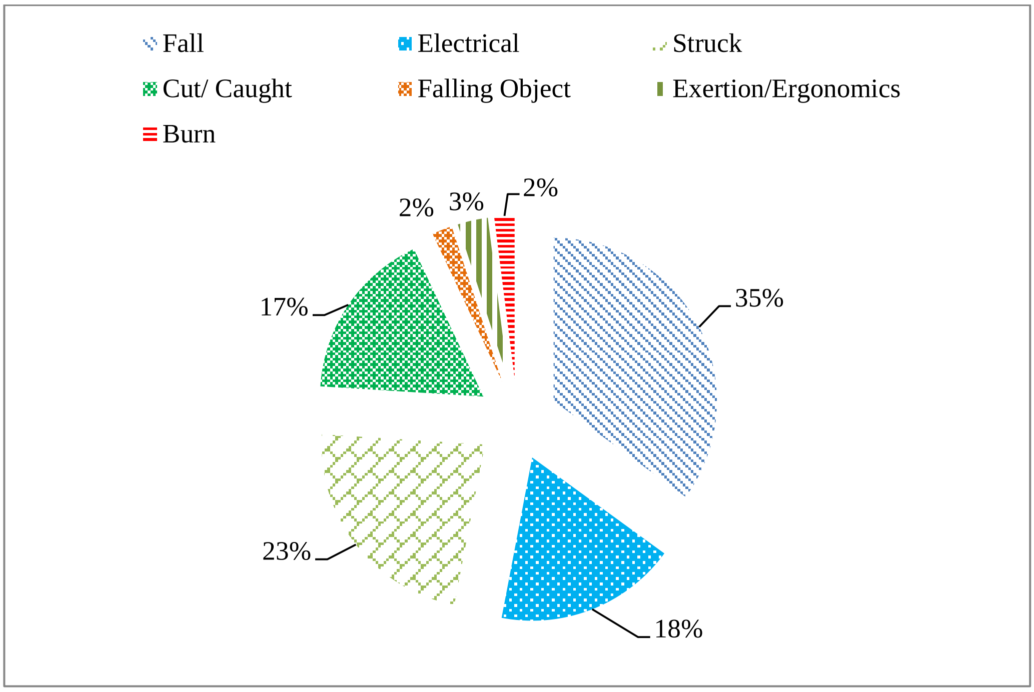


Figure 2. 18: Different Causes of Accidents in the Sample (total = 100 accidents)

Table 2. 5: Direct Cost of Accidents in the UK (HSE, 2011)

Description (Direct Cost)	Number of Accidents (2006-2007	Total cost (£ Million)	Conversion Factor (from £ to US$)	Total cost (US$ Million)	Cost Per Accident (US$)
Workplace Fatality	232	337	1.28766	433.94142	1,870,437
Major Injury	353,000	6,263	1.28766	8064.61458	22,846
Minor Injury	481,000	118	1.28766	151.94388	316
Illness	551,000	9,764	1.28766	12572.71224	22,818
Total:	**1,385,232**	**16,482**		**21223.21212**	

Similarly, the HSE (UK) report published in 2011, on the cost of accidents, which considered the 2006 – 2007 available data, established the direct cost of a total of 1385232 accidents and illness was US$ 21223.21 Million as shown in table 2.5 (HSE, 2011). The direct costs of one accident (fatal or non-fatal) in the UK will there cost US$ 15,300 if all the accidents including fatal, non-fatal with major or minor injuries and illness are considered. This direct cost of one accident in the UK (~US$ 15,300) is double the direct cost of an accident in South Africa (~US$ 7,260). This is maybe due to the fact the direct costs of one accident in the UK also include the cost of illness; however, the direct costs of an accident in South Africa don't include this. If the direct cost of an accident in the UK is calculated based on the fatalities and injuries accidents only, then this will be equal to US$ 10370; which represents a difference of 30% between the UK and South Africa accident costs. The UK direct costs of an accident (~US$ 10,370) is closer to the direct cost of an accident in the USA (~US$ 9,850), the difference is only 5%. If the average costs of the accidents which involve fatalities or major injuries are considered, the cost per accident in the UK will stand at US$ 24,000.

Statistics published the "Safe Work Australia" indicate that in 2012-2013, work-related accidents which resulted in injuries and illness put a burden of US$ 44.02 billion on the Australian economy. This is a huge amount which is equal to 4.10% of the total Australian GDP. The statistics further reveal that the majority of the cost (~95%) was borne by the workers and society. To be more specific, the workers bear 77%, society bear 18% and employers bear 5% of the total costs of accidents in Australia (AUS). Accidents that result in injuries are accounted for US$ 19.95 billion (~45%) of the total cost. Roughly, the direct cost of an accident in Australia is estimated at US$ 27,100, which is almost the same as the direct cost of an accident in the United States (~US$ 27,000).

The statistics related to the costs of accidents quoted from USA, UK, SA, and AUS show that the costs of accidents in these countries are not the same, but at the in the range of US$ 23,700 ~US$ 27,100 which gives an average value of the costs of an accident in these countries (~US$ 25,450) as shown in figure 2.20. These average costs of accidents ((~US$ 25,450) are used in this research for further analysis.

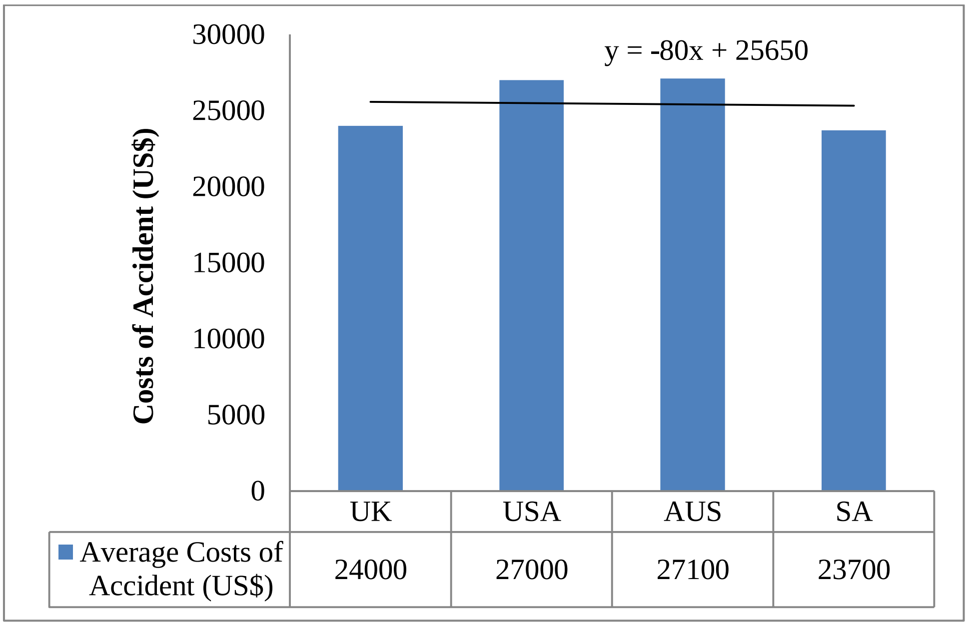


Figure 2. 19: Average Costs of Accident (UK, USA, ASU, SA)

As discussed in both of the above sections, the causes and costs of accidents are important in relation to improve safety performance; however there are regions specific factors such as climatic conditions including temperature and humidity as discussed in chapter 1, cannot be ignored. Both these factors contribute significantly to the heat stress which is discussed in the next section in more detail.

2.5 Heat Stress:

The global temperature statistics for the year 2011–2015 published by the World Meteorological Organization, show that the earth temperature, on average rose by 1°C in 2015. Intense high temperatures and heat waves repeatedly arrive throughout the year at low latitudes, and commonly at central latitudes in summertime (Hansen and Sato, 2016). In recent years, many high-impact disasters have been witnessed due to climate change, including drought in Eastern African regions between 2010 and 2012, which resulted approximately in 258,000 weather-related deaths; and the 2015 heat waves in the Indian subcontinent region, which led to more than 4,100 fatalities. Extreme heat stress has deep impacts on physiological responses, which result in work-related injuries, deaths and also reduce workers' productivity. Construction workers are expected to be affected more by heat stress comparatively more than the workers in other industries, due to the body heat generation caused by physically demanding work in the hot and humid working environment (Yi and Chan, 2017). Fatigue and stress caused by different factors have been considered as a major contributor to some of the world's most famous accidents including the disaster of the Exxon Valdez oil spill, which resulted in a spilling of approximately 41,000 m^3 of crude oil into the sea (NTSB, 1990-a). Heavy truck accidents are a particular problem in the United States with an estimate of 30–40% due to truck-driver fatigue as a contributing factor (NTSB, 1990-b). This is especially important for construction workers who frequently drive to and from sites in inclement weather and long distances – for example during the construction of nuclear power stations that need to be located away from populated areas. A key factor in fatigue and stress research is the circadian cycle – that is alertness levels depending on the time of day (Larsen et al., 2017; Mehta et al., 2017). Specifically, there is a drop in alertness during the early afternoon (figure 2.21). A study of the construction sector in Spain found that occupational accidents are more severe and possibly fatal if they occur between 13:00 and 17:00. The research conducted by Lópeza et al. (2011) found that times closer to the lunchtime is accounted for more than 18% of all accidents and approximately 29% of the accidents involving death. In the United States, a study found a spike in fatal accidents, accounting for 21.6% of all fatal accidents, between 14:00 and 16:00 (Banik, 2010). Figure 2.21 shows incidents of service strikes in the United Kingdom by the time of day. This illustrates an unexplained spike in incidents soon after midday. However, a comparison of a typical circadian cycle (relative ‘alertness’) shows a drop in alertness coinciding with the afternoon spike in service strikes. Further, the early afternoon spike is more pronounced on Mondays, when sleep-loss may also be a factor.

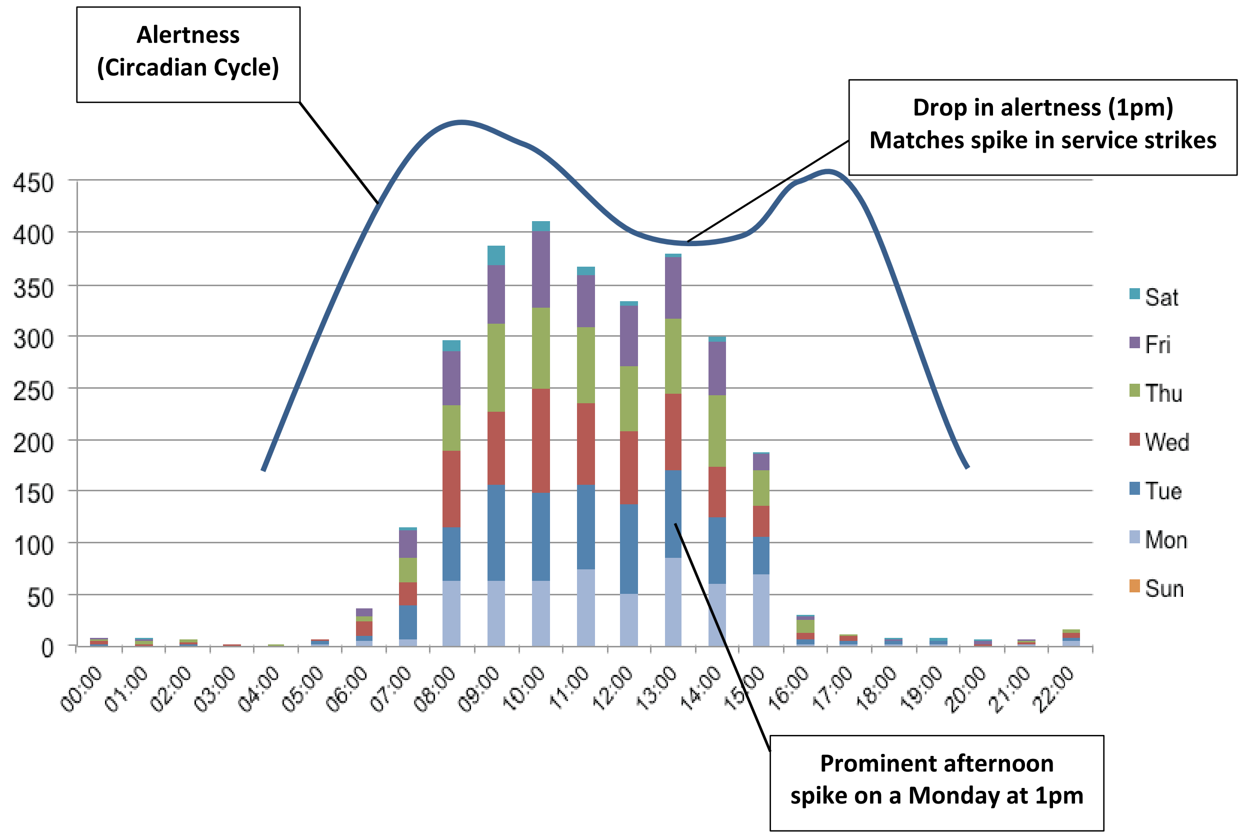


Figure 2. 20: Buried services strikes by time of day (USAG, 2015)

Similarly, exposure to the extreme temperature at work is regarded as a serious occupational health hazard that results in a variety of sickness or illnesses ranging from body pain to death. Exposure to severe and extended heat or humidity can decrease workers' energy and focus on their work, increase their irascibility, and lead them to heat-related sickness (Chan and Yi, 2016; Hancher and Abd-Elkhalek, 1998). Statistics reported by the Occupational Safety and Health Administration (OSHA) reveals that from 2003 to 2012, the number of workers deaths each year caused by heat-related sickness and injuries stood at 30 (OSHA, 2013). Data collected by the Center for Construction Research and Training in the United States statistics further reveal that 17 construction workers died due to heat-related factors in 2015 (NSC, 2017). Construction workers in general and those who engage in scaffolding and formworks, steel fixing and erection and concrete work are particularly considered to be the most affected workers due to heat stress. This is very simple to understand, as the daily tasks of these workers normally remain in an open area where they have to work under the direct sun's heat for several hours. There has been evidence that reflects the temperature of certain construction sites was noted to be more than the atmosphere temperate. For instance, Chan et al. (2012) concluded that the temperature of a construction site could be as high as 45°C even when the atmosphere temperature remains at 32°C. Middle Eastern region including Gulf Cooperation Council (GCC) countries are well known for their hot and humid climatic conditions. A report published in a daily newspaper on 22 January 2017, quoting a reference from World Meteorological Organization, stated that 2016 was the hottest on record where the temperature reached 50°C (MD, 2016). Similarly, a report published in a daily newspaper ‘Times of Oman’ on 10 August 2015, reported the temperature at 48°C (TOM, 2015). The annual temperature reported by the directorate general of metrology in Oman, however, shows that the maximum temperature was up to 40°C in the month of May and June as shown in Figure 2.22 (DGM, 2018). The summer period in Oman covers eight months of the year from March to October. Thus it is anticipated that construction workers in this region may have been highly affected by heat stress compared with those from other countries, however, this important issue has not yet been properly investigated. The proper understanding of heat stress and its impact on worker's production and safety performance may help construction organizations and government regulating body to develop strategies on how to protect workers from heat stress. Preventive actions such as work-break cycles, work management, and cool-down arrangement by providing drinking water or soft drinks were proposed in Hong Kong to secure the workers’ health and well-being in hot and humid working conditions (CIC, 2016; DH, 2010). OSHA instructions on safeguarding workers from heat stress can be adopted to handle safety and health-related issues (OSHA, 2017-a). Some of the OSHA guidelines indicated that the organization should adopt a comprehensive heat illness prevention programme. They (organizations) need to provide training to workers on how to protect themselves from the hazards that can lead to heat stress provide cool water in the construction area that is easily accessible to workers. At a minimum, each worker should have 500 ml of water for each working hour. Changing the work schedules and allowing frequent breaks so that the workers can take rest and water in shaded facilities is among the OSHA guidelines. Similarly, Increasing workloads gradually for those workers who are new to the heat and allowing more frequent breaks is a good practice to protect workers from heat stress. A similar approach should be applied to those workers who were away for a longer period so that they can adjust to working in hot conditions. Observing the situation at the site requires an experienced staff who observer conditions at the work area and safeguard workers who are at risk of heat stress. It is also important to consider the protective uniform that allows cooling.

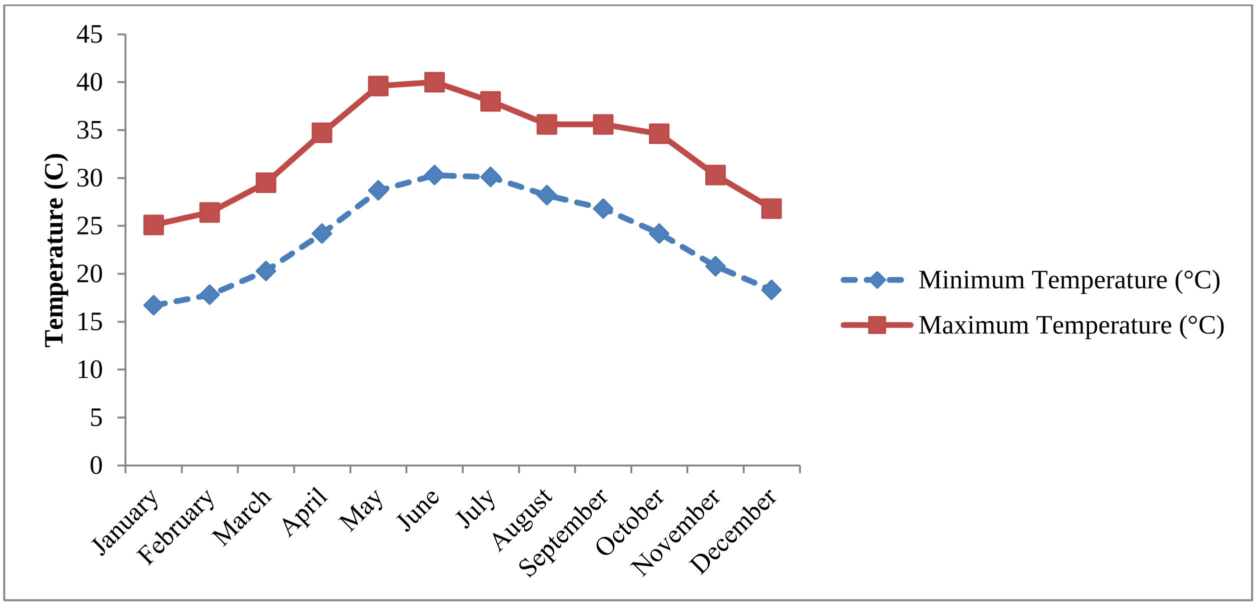


Figure 2. 21: Average Annual Temperature (maximum and minimum) in Oman

The research conducted by Yi et al. (2017) appraised the performance of recently designed clothing for construction workers in encountering heat stress. The tests and observations were carried out on volunteers while exercising in a hot and humid environment by wearing the traditional and the newly designed uniform. They concluded that their newly designed construction uniform could decrease thermoregulatory and cardiovascular stress, and enhance thermal relief. Liu and Wang (2017) observed that conventional safety management of heat stress primarily relies on the workers' awareness and behaviour. They presented a conceptual model to develop a self-intelligent workplace to manage workplace heat stress proactively, by integrating the features of a Geographic Information System (GIS) and Building Information Modeling (BIM). Most of the organizations hesitate to invest in safety, as a usual perception that it will cost huge amounts, which is technically not true if compared with the benefits from investment on safety. Research conducted in the United Kingdom on cost and benefit analysis revealed that when total costs of accident prevention were compared with the total benefits of accident prevention, the benefits far outweigh the costs of accident prevention by a ratio of approximately 3:1, which shows that when contractors, regardless of their sizes, spend £1.00 on accident prevention, they get a benefit of £3.00 (Ikpe et al., 2012).

Although, heat stress is directly linked with the environment temperature there is a high impact from relative humidity. The OSHA heat index guide considered both four levels of risk associated with high temperature as shown in table 2.6. The risk level could be lower if the temperature (heat index) is less than 32.8^{o} C. As the temperature increases, the risk level increase and particularly it reaches to extreme risk when the temperature is greater than 46.10^{o} C (OSHA, 2019). The OSHA has also considered the heat index developed by the United States, National Oceanographic and Atmospheric Administration (NOAA), which has combined both the environment temperature and relative humidity (Table 2.7). Based on this table, a temperature of 42.2^{o} C with a relative humidity of 40% can be of extreme danger for work. Since most of the GCC countries are located along the coast, the humidity is comparatively high in these countries.

Table 2. 6: OSHA Guidelines on Heat Index

Heat Index	Level of Risk	Preventative Measures
Less than 32.8°C	Low	Apply general heat safety and planning guidelines
32.8 to 39.4°C	Moderate	(i) Take up to 4 cups of water every hour (ii) Take frequent breaks as necessary
39.4 to 46.1°C	High	(i) Drink water every 15-20 minutes (ii) schedule frequent breaks (ii) Complete heavy work tasks when the heat index is lower
Greater than 46.1°C	Very High [Extreme]	(i) Take water frequently (ii) Reschedule heavy work (iii) Alert workers to heat index for the day and ensure all safety precautions.

RELATIVE HUMIDITY (%) \ TEMPERATURE (°C)	26.7	27.8	28.9	30	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	40	41.1	42.2	43.3
40	26.7	27.2	28.3	29.4	31.1	32.8	34.4	36.1	38.3	40.6	42.8	45.6	48.3	51.1	54.4	57.8
45	26.7	27.8	28.9	30.6	31.7	33.9	35.6	37.8	40	42.8	45.6	48.3	51.1	54.4	58.3	
50	27.2	28.3	29.4	31.1	32.8	35	37.2	39.4	42.2	45	47.8	51.1	55	58.3		
55	27.2	28.9	30	31.7	33.9	36.1	38.3	41.1	44.4	47.2	51.1	54.4	58.3			
60	27.8	28.9	31.1	32.8	35	37.8	40.6	43.3	46.7	50.6	53.9	58.3				
65	27.8	29.4	31.7	33.9	36.7	39.4	42.2	45.6	49.4	53.3	57.8					
70	28.3	30	32.2	35	37.8	40.6	44.2	48.3	52.2	56.7						
75	28.9	30	33.3	36.1	39.4	42.8	46.7	51.1	55.6							
80	28.9	31.7	34.4	37.8	41.1	45	49.4	53.9								
85	29.4	32.2	35.6	38.9	43.3	47.2	52.2	57.2								
90	30	32.8	36.7	40.6	45	50	55									
95	30	33.9	37.8	42.2	47.2	52.8										
100	30.6	35	39.4	44.4	49.4	55.6										

Table 2. 7: Heat Disorders with Prolonged Exposure Activity

Legend:

- Caution
- Extreme Caution
- Danger
- Extreme Danger

The average annual humidity both in Doha, the capital of Qatar and Muscat, the capital of Oman is reported to be 59%. The humidity in Dubai, the capital of the United Arab Emirates stands at 62%. Comparatively, most of the main cities in all GCC countries represent an annual humidity of more than 60%. Both the high temperature and humidity will have a significant impact on the worker's performance both in terms of productivity and safety. The existing literature fails to show this has been considered in the GCC region. This research project, therefore, attempts to consider heat stress, its impact on the worker's safety performance and develop guidelines that can be used to protect workers from the effect of heat stress. Of course, the provision of safety-related regulations becomes important when it empowers workers to refuse when there is safety risk at the workplace. The next section, therefore, explores the current occupational safety and health regions applicable to construction organizations in Oman.

2.6 Occupational Safety and Health Regulations:

Poor occupational safety and health (OS&H) results in an economic burden of 4% of the total world Gross Domestic Product (GDP). Effective OS&H regulations and their implementation are one of the main factors in achieving improved safety performance. Safety performance is directly linked to individual behavior, organization commitment, and compliance. The role of a safety regulatory organization in this regard is an important one in the implementation of the safety and health regulation across all industries. For instance, in the USA, statistics indicate that ”Worker deaths” in America are down, on average, from about 38 worker deaths a day in 1970 to 14 a day in 2016, and “Worker injuries and illnesses” are down from 10.9 incidents per 100 workers in 1972 to 2.9 per 100 in 2016 (OSHA, 2016). The reduction in deaths and injuries in the USA was obviously due to the improvement of worker's safety and health condition which includes the relevant regulations and their implementation, accountability on poor safety and health status, and realization of the benefits of improved safety and health performances. It is clearly reflected in the data of those countries which show improved safety and health performance, that they have a proper system of accountability on poor safety and health outputs. Such a system of accountability includes safety inspection, prosecution and punishment by a regulatory authority according to law.

There has been evidence that reflects that the cost related OS&H is rapidly increasing in Oman. Statistics published by the Public Authority of Social Insurance in Oman which registers only Omani citizens show that the expenditure related to OS&H rose from 1 Million OMR (=2.6 Million US$) in 2012 to 2.9 Million OMR (=7.53 Million US$) (figure 2.20). Although the number of active insurees also increased in this period from 172,066 in 2012 to 227,193 in 2016 which represents a growth of 32% (figure 2.23), however, the increase in OS&H expenditure in the same period was 200%. The Ministry of Manpower, Oman, is mandated to oversee the implementation of current OS&H regulations. The data from the Ministry of Manpower reveals that a total of 1,328 inspections were made in the year 2016. A total of 569 warning notices were issued to companies, which were found not complying with the regulations. This number is comparatively more than in 2015 where the total number of warning notices was at 555. The total cases which were referred to the court of law in 2016 were six (6), while in 2015 there was only one case which was referred to the court of law (MoM, 2015, MoM, 2016). Similarly, a report published in the daily Times of Oman, dated February 28, 2015, states that there are no official statistics of how many company workers get hurt in the course of their duties. However, according to the individual Health and Safety Environment's (HSE) records of the top 10 contractors, more than 3,700 of them needed medical treatment in 2014. The injured workers who were hospitalized made up nearly 10 percent of the total workers on this list. Tragically, about 18 percent of them died either at the sites or in hospitals last year. In comparison to the previous year, 246 more workers got injured in 2014 but for obvious reason, company directors do not want this part of the record to be made public (TOM, 2015-a). One of the possible reasons for this might be a lack of awareness of current OS&H regulations and their effective implementation in Oman. Other reasons may include the financial and managerial capabilities of small and medium enterprises (SMEs). For instance, Masi et al., (2014) stated that SMEs have fewer financial and human resources at their disposal. Thus, under conditions of economic uncertainty, managers of SMEs are reluctant to spend time and resources on problems that do not arise on a regular basis and this would certainly include safety and health issues (MacEachen et al., 2010; Agumba and Haupt, 2012). In Canada, a SME is defined as a company with a staff of fewer than 100 employees, and such enterprises represent 98% of all businesses and employ 67% of the workforce in some parts of the country (Statistics Canada, 2013). Mendeloff et al., (2006) noted that workplace fatal accidents are up to eight times more frequent in SMEs, and nonfatal accidents are as much as 50% more likely to occur in SMEs (Fabiano et al., 2004). Officially, in Oman, there are 100,000 registered construction organizations with a total workforce of 725,000, indicating that the majority of these organizations fall under the definition of SMEs. These organizations experience challenges with regard to improving occupational safety and health performance (OSC, 2016; Umar, 2016).

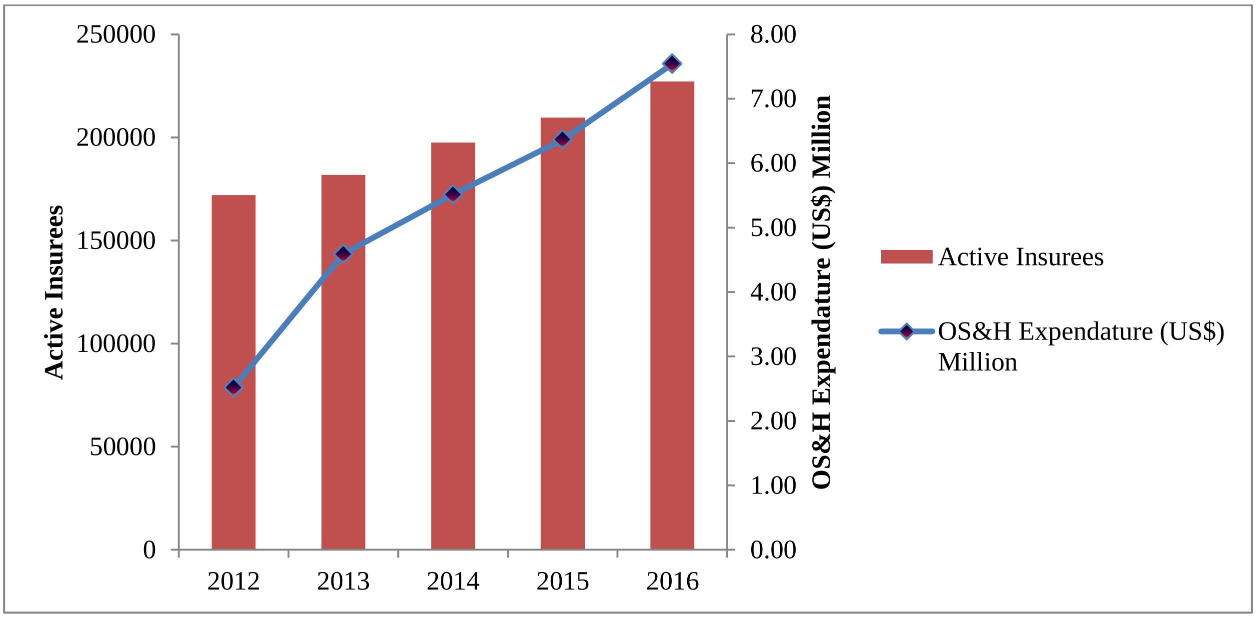


Figure 2. 22: An Increase in OS&H Expenditures with Respect to Active Inssurees in Oman (PASI, 2012; PASI, 2013; PASI, 2014; PASI, 2015; PASI, 2016).

The situation around safety and health and the availability of related data is, however, more or less the same in all GCC countries. In the UAE, when the Abu Dhabi municipality first collected accident data for a full 12 months in 2010, it was revealed that there were 101 deaths due to occupational injuries. Workers falling from heights and being hit by falling objects were the most common hazards for labourers on the sites. Unsafe scaffolding and open shafts were also some of the common hazards (The National, 2012). In Oman, the major portion of work-related injuries arises from road traffic accidents (36.6%) followed by slipping and falling of workers (19%) and then getting crammed between solid objects (12.4%), as shown in figure 2.24. This represents the data of Omani workers registered with Public Authority of Social Insurance in Oman, thus the collection and analysis of such data for all workers in Oman will help to develop strategies to avoid such causes of accidents in the future (Umar and Egbu, 2018).

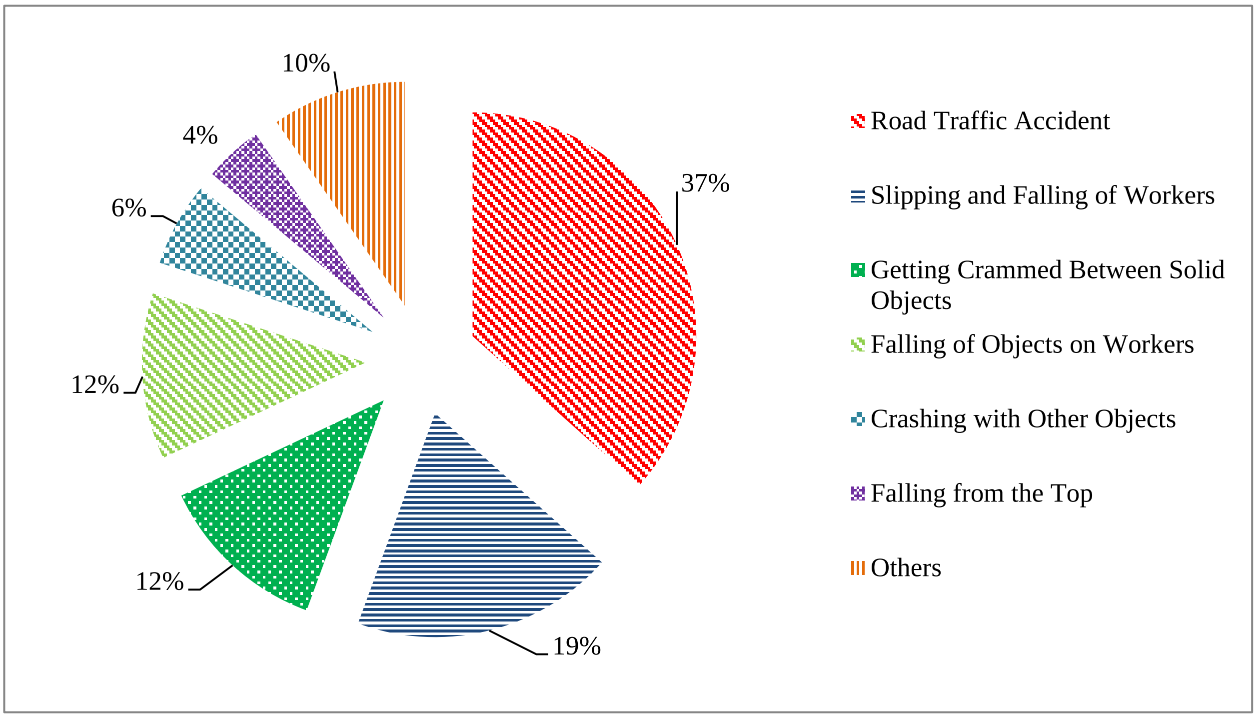


Figure 2. 23: Causes of Work-Related Injuries in Oman (PASI, 2016)

Since the 1970s, Oman has been witnessing steady progress in the political and socioeconomic fields. However, the country has had to rely on expatriates to implement its ambitious socio-economic programs (of five-year consecutive development plans) due to the limited number of qualified Omanis in the areas of occupational safety & law. The Ministry of Manpower is facilitating the issuance of permits for foreign workers, especially in the sectors that witness shortages in the number of qualified national workers. Articles 27, 40, 41, 87, 88, 89, 90, 98 and 99 of the Ministry of Manpower Labor Law stress that both workers and employers are to abide by the health and safety regulation mentioned in these articles (RD, 35/2003). Oman has other decrees namely; Sultanate Decree No. 40/1977: Occupational diseases and accident compensation law, Ministerial Decree No. 19/1982; Occupational Health and Industrial Safety Precautions, and Ministerial Decree No. 286/2008; Regulation of Occupational Safety and Health (SD, 40/1977; MD, 19/1982; MD, 286/2008).

Based on the stipulation of the Labour Law which entitles the Minister of Manpower to issue regulations, occupational safety and health have been regulated under Ministerial Decision No. 286/2008, namely the Regulation of Occupational Safety and Health, for establishments governed by the Labour Law (MD, 286/2008). This Regulation is regarded as the framework legislation in OS&H at the level of the Sultanate. It supersedes the Occupational Health and Industrial Safety Precautions issued by Ministerial Decision No.19/1982, which address general provisions regarding safety at work and the protection of the health of the workers in private-sector establishments. The precautions in 1982 regulations consist of two chapters and fourteen articles which cover a number of aspects presented in appendix I (MD, 19/1982):

The new Regulation applies to all establishments which are subject to the Labour Law. Its provisions are covered by 4 Chapters and 43 Articles (MD, 286/2008).

Chapter 1 of the Regulation covers definitions of the terminology used in the text under Article 1.

Under chapter 2, article 3, entitles the Ministry of Manpower Inspector to:

i. Enter work sites without prior notice during the working hours;

ii. Check the properties of the materials used and to take samples for analysis;

iii. Require medical and laboratory investigations for the purpose of assessing the effects of exposure;

iv. Conduct the necessary investigations and look at records for the purpose of ensuring compliance with the Regulation;

v. Instruct the employer to take measures needed in alleviating the dangers associated with work and raise awareness regarding protection against such dangers.

The Regulations also authorize the inspector to issue warnings and order partial or total stoppage of activities in cases of imminent dangers, with the backing of the Royal Oman Police if necessary. Whilst they are required to maintain business secrets, the inspectors explain the employer's responsibilities to inform workers of the hazards associated with work provide the needed personal protection, display safety instructions in a prominent place at the workplace, and to keep the results of periodic monitoring and exposure to hazards in a special registry. Workers are also reminded of their duties to follow safety instructions and to refrain from any action to obstruct implementation of safety measures, for the purpose of protecting themselves and their fellow workers from injuries. Under this Chapter, the responsibilities of employers who employ 10 or more workers are defined in detail, so as to cover the establishment's OS&H policy, including the organization and management of OS&H, specific hazards, emergency plans, training, monitoring, testing of protective devices and materials, medical examinations, investigation of accidents and arrangements for handling workers' complaints. The employer's OS&H policy and programme are subject to the approval of the concerned Department or Section at the Ministry of Manpower.

Article 15 of the Regulations specifies the actions of the employer needed for providing a safe and healthy workplace. For instance, the worksite, buildings, materials and all the equipment used for work must conform to the technical specifications. Paragraph two of the same article states that the size of the building must be adequate to the size of the operations executed in the building. Similarly, the work materials coming from one work area should be directly used by the next work area without being transferred across a far distance. Movable storage shelves, carriers, revolving cylinders, conveyor belts or any other adequate method should be used to transfer the materials from one work area to the other. Provisions of facilities at the workplace which include lighting, ventilation, hot and cold drinking water, sleeping quarters, eating facilities, changing of clothes and restrooms are covered under Article 16.

Chapter 3 of the Regulation covers work uniforms and Personal Protective Equipment (PPE), first aid, medical checkup, analysis and arrangement in cases of diagnosing occupational diseases. The protection of women workers is also covered in this chapter.

Chapter 4 (articles 29-43) addresses in detail the following topics:

i. Protection of the disabled;

ii. Fire hazards;

iii. Mechanical and electrical hazards;

iv. Hazards of lift tools, heavy-duty machinery, and workers' transport buses;

v. Boilers, vapour and air reservoirs;

vi. Chemical hazards;

vii. Radiation, occupational cancer, and asbestos;

viii. Special precautionary measures (construction, drilling, demolition, and civil engineering);

ix. Agriculture and animal breeding (tools and machinery; manual fieldwork; use of insecticides and fertilizers);

x. Seaports.

Annexed to the Regulation are five tables and schedules on:

Lighting levels;

i. Limits of exposure to low temperatures;

ii. Limits of exposure to noise;

iii. Required checkup and analysis according to the type of exposure to some occupational diseases;

iv. Limits of exposure to radiation.

The OS&H regulations in different countries that display an improved safety performance are reviewed, revised and updated on a periodic basis. In most of the countries, there are separate OS&H regulations for the construction industry. There appears to be a need to review the existing regulations in Oman which were developed and enforced in 2008, to find the weak areas of the regulations and how these areas can be improved. Apparently, even if there are up to date regulations exist, however, if they are not enforced in a true letter and spirit, the outcomes will not be of the desired level.

The existing literature also shows that the workers' health-related factors are considered an important element which supports to achieve a safe workplace. To expand this, the next section discusses the workers' health factors and body pain with a specific reference to safety and productivity performance.

2.7 Workers Health Factors and Body Pain:

Delay in the construction project is a usual phenomenon around the world that occurs due to several internal and external factors which include poor definition and tracking, technical barriers, inadequate resources, changing priorities, wrong project, weather, competitors and legal barriers (Nicholas and Steyn, 2017). Assaf and Al-Hejji (2006) observed that 30% of the construction projects in Saudi Arabia complete on time while the remaining 70% are delayed. Similarly, the National Audit Office report in the UK, quoting the data before the year 2000, shows that 70% of the government construction project delay (NAO, 2003). Workforce related factors such as labour productivity, labour skills, and labour availability are regarded some of the key delaying factors by many researchers (Kaming et al., 1997; Chan and Kumaraswamy, 1997; Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Umar, 2018).

Many researchers have linked the productivity and safety performance of construction workers with their physical health (Groeneveld et al., 2008; Claessen et al., 2009; Yi and Chan, 2016; Yi and Chan, 2017). There have been several research studies on the physical examination which were carried out among different occupations and industries. Body Mass Index (BMI) and body blood pressure were some of the common factors which were considered in these studies. A BMI measurement is used to determine if an adult is at a healthy weight for their height. An individual BMI is calculated by dividing their weight in Kg by the square of their height in m^2. The BMI values from 18.5 to 25 are considered as normal (WHO, 2017). For example, an adult who is 17.5 m tall and weighs 70 kg will have a BMI of 22.9, which is in the normal healthy range (table 2.7). To calculate the BMI, the weight and the height of the participants need to be measured and the BMI of each participant can be then calculated using equation 2.1. After calculating the BMI, table 2.8 can be used to determine if an adult is at a healthy weight for their height.

$BMI = \frac{W}{H^2}$ …………………Equation 2.1

Where;

BMI = Body Mass Index

W = Weight in Kg

H = Height in meter

Table 2. 8: Interpretation of BMI Results (CDCP, 2019)

BMI	Weight Status
Below 18.5	Underweight
18.5 – 24.9	Normal or Healthy Weight
25.0 – 29.9	Overweight
30.0 and Above	Obese

Similarly, high blood pressure is regarded as the main cause of hypertension (Daskalopoulou et al., 2015). Poulter et al. (2015) concluded that if a person is having blood pressure greater than or equal to 140 mmHg systolic blood pressure (SBP) or greater than or equal to 90 mmHg diastolic blood pressure (DBP) is to be classified hypertension. Carey and Whelton (2018) noted that hypertension is the leading cause of death and disability worldwide. A research study carried out to describe the cardiovascular health of construction workers in Hong Kong considering a total of 626 construction workers, in which a number of parameters including blood chemistry, blood pressure, weight, and height were measured, founded that two-thirds of the construction workers achieved only three out of the seven “ideal” cardiovascular health metrics (Chung et al., 2018). Construction worker's cardiovascular health is important not only due to the fact that they required to perform the heavy physical demanding jobs but they are also consistently open to harsh environments filled with fumes, dust, heat, and moisture. Cardiovascular diseases and musculoskeletal pain are regarded as some of the main causes of early retirement among construction workers (Brenner and Ahern, 2000; Dong et al. 2008). A research study carried out by Sánchez-Chaparro et al. (2006) considering Spanish workers concluded that construction workers, when compared with workers from other sectors, are 15% more likely to have hypertension and 9% more likely to have diabetes. Another research study carried out in Germany considered construction workers from age 40 – 64 years, founded that construction workers are 56% more likely to be obese compared to other white color workers (Arndt et al., 1996). Generally, obesity and overweight result in increased blood pressure which could also cause hypertension. Overall the blood pressure can indirectly affect the physical abilities of a human, thus such workers are more open to accidents (Beevers and MacGregor, 1999). The blood pressure of a participant can be further classified (normal ~ hypertension) using the WHO recommended values in table 2.9.

Table 2. 9: Classification of Blood Pressure (BPA, 2008)

Blood Pressure Category	Systolic Blood Pressure (SBP) – mmHg (upper value)	Diastolic Blood Pressure (DBP) – mmHg (lower value)
Normal	Less than 120	Less than 80
Elevated	120 - 129	Less than 80
Hypertension – Stage I	130 - 139	80 - 89
Hypertension – Stage II	140 or higher	90 or higher
Hypertensive – Crisis	Higher than 180	Higher than 120

Kawai et al. (1995), for instance, considered the BMI in a research study conducted to assess the health profile of 816 white-collar workers in Japan. According to Dua et al. (2014), an increased BMI being linked with prehypertension may advise that such persons are at high risk of progressing to frank hypertension. A research conducted in Denmark by Gupta et al. (2018) reported the BMI of 147 blue-collar workers from a variety of professions including construction and observed that BMI of 59% of the participants was more than 25. The mean value of the BMI of the selected participants was 26.4$\pm$4.80. Similarly, the mean BMI of 932 construction workers in Hong Kong reported by Yi and Chan (2016) was 24.3$\pm$3.70. Their reported BMI results further reveal that 2.8% of the participants were underweight, 36.1% were overweight and 6.5% were obese. The finding of similar research conducted on 314 male construction workers in the Netherland shows that based on the BMI results, 70% of the participants were classified as overweight and 22.7% as obese. (Viester et al., 2017). The BMI result from different studies, however, clearly reflects that the majority of construction workers are not in healthy condition, which will have different consequences. Similarly, musculoskeletal pain is common in construction workers worldwide (Goldsheyder et al., 2004; Boschman et al., 2012). This is because construction workers required to perform physically demanding tasks repeatedly with an awkward position and more force. Construction worker's body pain is considered as one of the most important causes of accidents at construction sites (Yi and Chan, 2016). 77% of the total construction workers around the world are recognized to have musculoskeletal pain or disorder (Punnett and Wegman, 2004). For instance, in Taiwan, 76.2% of the construction workers reported the body pain and the most frequently reported areas for such pain were the shoulders, neck, and low back (Leung et al., 2012). The results of a survey from the US construction industry reveals that approximately 77% of the workers suffer from musculoskeletal pain, while the lower back area was the most frequently reported for such pain (Goldsheyder et al. (2004). A study conducted by Hanklang et al. (2014) on musculoskeletal disorders and pains among Thailand female construction workers, reported that around 58% of these female workers experience body pain while the mostly reported area for such pain remained lower back and shoulders. Musculoskeletal disorders and pains are further considered as a major cause for disability, absenteeism and reduced workability. For instance, in Canada, the injuries caused by musculoskeletal pain or disorder result up to 47% of the total injuries claims and around 42% of the lost time claims (ACSA, 2008). A research study conducted in the United States on occupational musculoskeletal disorders among construction workers considered the data from 1992 – 2014 and founded that musculoskeletal disorders remained higher than all other sectors even combined. The study further reveals that musculoskeletal disorders resulted in an economic burden of US$ 46 Million in 2014 (Wang et al., 2017). Musculoskeletal disorders and pain remained very common among the construction workers in Australia, accounted for 10,875 (12.7%) of the serious claims during 2009 – 2014 as shown in table 2.10. Similarly, back of the body was reported as the main area for the musculoskeletal disorders accounted for 35.10% of all musculoskeletal disorders followed by shoulders (16.10%) and knees (13.20%) in the same period in Australia as shown in table 2.11 (Safe Work Australia, 2016).

Table 2. 10: Serious Musculoskeletal Disorders claims by occupation in Australia

Occupation	Number of claims	Percentage of claims	Number of claims per million hours worked
Labourers	**85 750**	**23.8%**	**11.3**
Food process workers	6 180	7.2%	12.0
Cleaners and laundry workers	15 115	17.6%	10.5
Farm, forestry and garden workers	7 150	8.3%	9.6
Construction and mining labourers	10 875	12.7%	8.3
Food preparation assistants	5 175	6.0%	6.1
Community and personal service workers	**66 480**	**18.5%**	**9.5**
Health and welfare support workers	13 225	19.9%	15.8
Defence force members, firefighters and police	8 805	13.2%	15.0
Personal carers and assistants	22 815	34.3%	14.7
Prison and security officers	5 390	8.1%	9.1
Hospitality workers	5 405	8.1%	3.7
Machinery operators and drivers	**56 920**	**15.8%**	**8.4**
Store persons	11 440	20.1%	11.1
Machine operators	5 505	9.7%	10.5
Truck drivers	17 970	31.6%	10.3
Mobile plant operators	8 170	14.4%	6.1
Stationary plant operators	5 935	10.4%	5.2
Technicians and trades workers	**57 370**	**15.9%**	**4.4**
Fabrication engineering trades workers	5 410	9.4%	6.4
Bricklayers, and carpenters and joiners	6 060	10.6%	6.4
Mechanical engineering trades workers	5 745	10.0%	4.1
Food trades workers	5 675	9.9%	4.0
Sales workers	**22 185**	**6.2%**	**3.3**
Professionals	**35 595**	**9.9%**	**1.7**
Midwifery and nursing professionals	11 975	33.7%	6.2
School teachers	7 335	20.6%	2.3
Clerical and administrative workers	**20 000**	**5.6%**	**1.6**
Managers	**14 125**	**3.9%**	**1.1**
Total	**360,180**	**100.0%**	**4.2**

Table 2. 11: Bodily location of Musculoskeletal Disorders in Australia

Bodily location of Musculoskeletal Disorders	Musculoskeletal Disorders injuries	Musculoskeletal Disorders diseases	All Musculoskeletal Disorders
Back	32.5%	43.3%	35.1%
Shoulder	15.2%	18.8%	16.1%
Knee	14.6%	8.7%	13.2%
Ankle	7.5%	1.2%	6.0%
Wrist	4.0%	5.5%	4.3%
Hand, fingers, and thumb	3.3%	3.4%	3.3%
Neck	2.7%	4.5%	3.2%
Elbow	1.9%	6.0%	2.9%
Foot and toes	1.7%	1.3%	1.6%
Neck and shoulder	1.6%	0.7%	1.4%
Lower leg	1.7%	0.5%	1.4%
Other	13.3%	6.2%	11.6%
Total	**100.0%**	**100.0%**	**100.0%**

A research carried out in the United States compared the rates of medical insurance claims for musculoskeletal disorders between workers in a construction trade and a general worker population to determine if higher physical exposures in construction lead to higher rates of claims on personal medical insurance. The results of this study showed that 51% of the construction workers (floor layers) experienced musculoskeletal diagnosis for one or more body parts (Dale et al., 2015). Similarly, a systematic review on the prevalence of musculoskeletal symptoms in the construction industry reported by Umar et al., (2018), that prevalence of musculoskeletal symptoms was 51.1% for lower back, 37.2% for knee, 32.4% for shoulder, 30.4% for the wrist, 24.4% for neck, 24.0% for ankle/foot, 20.3% for elbow, 19.8% for upper back, and 15.1% for hip/thigh.

Although construction is a major industry in Oman and other GCC countries, however, less attention is given to this topic as part of the workers' wellbeing. In reality, a better understanding of workers’ body pain will help construction organizations to make strategies to improve the work and health-related elements which can be helpful in managing such pain. Such efforts will benefit both the workers and organizations. The absence of worker's body pain will increase their wellbeing and the organizations will be benefited through improved productivity and safety performance.

The discussion made in the above sections associated with the causes, costs, heat stress, safety regulations, and worker's health factors are important, however, it is clear that such factors are only considered when organizations are ready to accept and give values to them. This, however, cannot be achieved without a rich organizational culture and a mature organizational climate. The next sections, therefore, explain the safety culture and safety climate and put light on the main factors/ dimensions associated with this area.

2.8 Safety Culture and Safety Climate:

The focus on elements that impact safety and safety improvements within organizations has been shifted in the last century. Scientists and experts have established the safety culture and safety climate as a fundamental element in curtailing injuries, illnesses, and deaths at the workstation. Safety climate may be classified as a subgroup of organizational climate which provides a direction to safety management, complementing the frequent predominant engineering path. An understanding of the safety climate elements can be helpful in improving the safety performance of a construction organization. Additionally, safety climate findings are regarded to be more precise (e.g. multi-sliced) and are pro-active ground for improving safety, rather than reactive (after the fact) data from accident numbers and accident and incident investigations (Seo et al., 2004). Hale and Hovden (1998) define three periods of safety which include the technical period (1920's), the human factor period (1970's) and the management system period (1980's). The third period of safety spread-out the attention to include safety culture, and thus the approach of safety culture was accurately presented and delineated after the Chernobyl accident which took placed in 1986 (INSAG, 1992). Thus, enthusiasm in the approach of safety culture has been increased as safety researchers and practitioners have solicited to characterize and operationalize this approach (Clarke, 2000). One of the reasons for this is that rich safety culture and a mature safety climate are considered among the most important elements in attaining a safe workplace (Bergh et al., 2013). To enhance the level of safety culture and safety climate, it is crucial to, first gauge the existing level of safety culture and safety climate, then agree what level of safety culture and safety climate is required, obtainable and desired, and then to make strategies to accomplish the safety culture and safety climate, which is desired (AIChE, 2012).

Safety climate can be defined as common understandings between the employees of a social unit, of policies, procedures, and practices connected to safety in a business (Kines, et al., 2011). The Center for Protection of Worker's Right (CPWR) and Centre for Construction Research and Training defined safety climate as workgroup members' common thoughts of management and workgroup safety-related policies, procedures and practices (CPWR, 2014). Many construction organizations are trying to enhance safety climate gauges as a way to step closer to the target of obtaining zero accident workplaces (CPWR, 2014). Similarly, Zohar (1980) described the safety climate as a view of workers' understandings about the respective significance of safer acts in their work-related behaviour. There are several definitions of safety culture endorsed by researchers; however, the Cox and Cox (1991) definition appears to be more concise and simple. They described safety culture, as the attitudes, beliefs, understandings, and values that employees contribute in connection to safety. Scientists and experts have established the safety culture and safety climate as a fundamental element in curtailing injuries, illnesses, and deaths at workstations. The process of using safety climate assessment tool to improve safety performance in construction organizations as described by Umar and Wamuziri (2017) as shown in figure 2.25. The concept of using safety climate approach in Gulf Cooperation Council (GCC) member countries was first truly discussed by Umar and Wamuziri (2016-a). Umar and Egbu (2018) reported different safety climate factors relevant to the construction industry in Oman. The main drawback of this study was that the data was collected from a small number of respondents using a semi-structured interview approach. The only justification for using this approach of research with a limited number of respondents mentioned by the authors was the nature of study which they claim as exploratory.

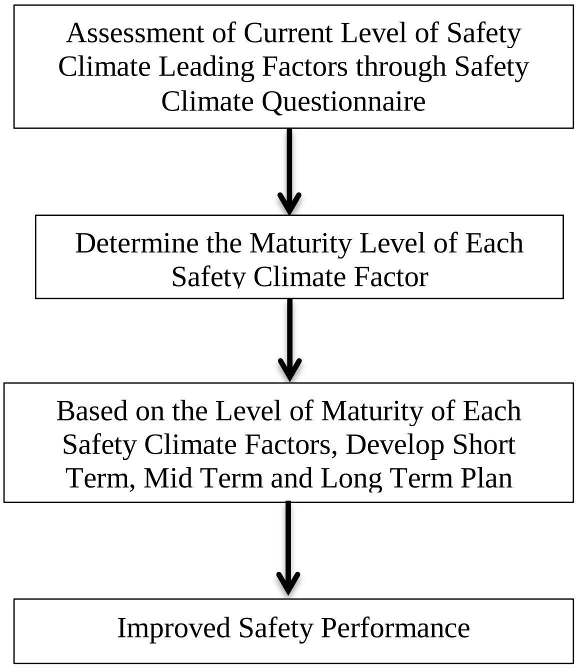


Figure 2. 24: Process of Using Safety Climate to Improve Safety Performance (Umar and Wamuziri, 2017)

The literature review suggests that there has been great workaround carried out around the topic of safety culture and safety climate since 1980. A number of key factors that have a high impact on organization's safety culture and safety climate have been considered by many researchers. The review of these factors is considered important in order to develop a safety climate assessment tool for Oman and GCC construction industry. In the next sections, some of these factors are discussed.

2.8.1 Management or Organizational Commitment towards Safety:

One of the most common factors used in the identified safety climate tools can be referred to as management or organizational commitment towards safety. The first safety climate assessment tools designed by Zohar in 1980 was consist of 40 items covering eight different safety climate dimensions or factors and the first one was management attitude toward safety (Zohar, 1980). Management or organizational commitment toward safety can be displayed in a variety of ways. The literature review around management commitment suggests that in organizations where the number of accidents is low, top managers of those organizations were found to be involved personally in all safety-related issues on a routine basis (Cohen et al., 1975; Zohar, 1980). On the other hand, a similar commitment was not evident in organizations with a high rate of accidents (Shafai-Sahrai, 1971; Cleveland et al. 1978; Zohar, 1980). In commercial organizations, the business priorities are informed through the top managers of that organization. Thus directly or indirectly these mangers are the main source of information related to the priorities and goals of such organizations (Kines et al. 2011). They further quoted that organizational climate theories reflect that worker's safety behavior is based on the organization's rules, policies, procedures, and practices. If in these rules, policies, procedures, and practices safety gets priority, it will be reflected through workers' safe acts. Similarly, if safety remains one of the organizational priorities, it will be informed through the top managers of organizations which could be helpful in promoting a safe working environment. Overall, the discussion suggests that organizational or management commitment has a major impact on promoting safety culture in the organizations, thus this needs to be considered as part of the safety climate assessment tool.

2.8.2 Safety Training:

Zohar (1980) while discussing and comparing the organizations with a high number of accidents and low rates of accidents found that emphasis on safety training was the second factor that differentiates these organizations. Similarly, in mature organizations safety training for new workers was found to be an integral part of their orientation (NSC, 1969; Cohen et al., 1975). Follow up and periodic training of workers is carried out on a routine basis in these organizations. In a review of different safety climate tools conducted by Flin et al., (2000) observed that necessary safety training for workers was one of the main factors used in these scales. A research study carried out by Zahoor et al. (2016) related to occupational safety and health performance in the Pakistani construction industry, concluded that safety training is on the top of the most neglected factors. In construction projects, workers are expected to works with different machines and equipment during the execution cycle of the project. This it is important that such workers should have enough knowledge of the operation of the equipment. Umar and Egbu (2018) in their research on the root causes of accidents in construction projects, analyzed 623 accidents and noted that 14% were caused by machines and equipment. Such accidents can only be reduced when workers have appropriate training incorporating both operational and safety components. The finding of the research conducted by Neal et al. (2000) emphasizes that apart from specific safety training (work-related), training which highlights the importance of safety has a greater effect to enhance the overall organizational climate. The Center to Protect Workers' Rights (CPWR) and The National Institute for Occupational Safety and Health (NIOSH) in the United States had organized a two days' workshop in June 2013 to improve the understanding of the safety climate (CPWR, 2017). A total of 72 nominated construction stakeholders representing the broad of the industry participated in this workshop. The participants of the workshop were from abroad of the industry including 25% representation from contracting organizations, 12% from employer associations, 14% from workers associations, 40% from researchers and academics, 6% from consulting organizations (6%), and 4% from insurance companies. The participants concluded that safety training is one of the main factors of safety climate and needs to use in the assessment tools. In general, the observation leads to the conclusion that the safety climate of a construction organization or a construction project could not be completely measured without considering the factor of safety training.

2.8.3 Employees Involvement in Safety:

Employee's safety involvement refers to the activities undertaken by workers at the workplace which includes the assistance of colleagues, encouraging safety compliance at the workstation, demonstration of safety initiatives and attempt to enhance the safety performance at the workstation. The employee's perceptions related to safety risk and control can be directly linked to their participation and responsibility for safety. It has been evident by Walter and Haines (1988) that employees mostly give importance to discrete responsibility when it comes to work-associated safety and health matters. This finding further appears to be consistent with the finding of Frenkel et al. (1980) and Nelkin and Brown (1984). They noted that employees depend on their personal efforts to manage occupational safety or health-related issue to work station despite asking the help or assistance from management or other sources. This is however not the case in construction workers. The study conducted by Dedobbeleer and Beland (1991) on the measurement of safety climate in construction projects observed that construction workers consider safety as a nexus between the workers and organizational management. The safety climate suggested by the above two authors, therefore, has only two factors i.e. (i) organizational commitment towards safety and (ii) employees participation. Since the knowledge and understanding of safety climate have widely expanded, therefore considering only management commitment and worker involvement in a safety climate assessment tool may not serve the purpose. The limited number of factors in this tool was, therefore, one of the main drawbacks, but this doesn’t warrant the credibility of these factors. The participation of workers in safety was one of the factors in the safety climate tool developed by the Health and Safety Executive in the UK (HSE, 1997). Workers' participation in safety was further regarded as an important factor in safety climate assessment tools. For instance, the safety climate tool developed by Seo et al. (2004) considered the workers' participation important not only in the safety-related matters but also in the decision associated with safety. This factor was continuously considered and placed in the safety climate assessment tools developed in later years (Pousette et al. 2008; CPWR, 2017).

2.8.4 Workers Safety Behavior:

The current literature around safety and health-related issue suggest that personal factors including noncompliance with safety guideline either by an error or mistake could result into accidents at the workplace (Neal et al. 2000; DeArmond et al. 2011; Umar and Egbu, 2018). An important factor to understand that why occupational accidents take place at the workstation is to see the contribution of workplace behavior jointly developed by the group of workers in that place. Fung et al., (2016) in their research on safety awareness of construction workers explored the external factors with the psychological climate that the workers possess on their safety awareness. The model proposed by Umar and Egbu (2018) to trace the causes of accidents involves a variety of factors associated directly with workers behavior. When this model was applied to a highway project to access the causes of accidents in that project, it was revealed that 41% of the accidents on that project were due to those factors directly linked with the workers. Simulation-Based research conducted by Nasirzadeh et al. (2017) observed that unsafe behaviour of different agents is varied throughout the project duration due to the interactions with other agents as well as the safety-related regulations that exist in the site. Campbell et al. (1993) viewed the workers' individual factors such as adherence and compliance of safety procedures are important in safety performance but these factors are highly influenced by workers' knowledge, skill, and ambition. Earlier the model for safety performance proposed by Neal and Griffin (1997) had two factors for safety performance i.e. compliance and participation of workers. The results of a research conducted by Clarke (2006) using the meta-analysis technique, suggested that there is a difference between safety compliance and safety performance. Safety compliance can be referred to as the adherence of organizational safety guidance and performing the work-related task in a safe way. DeArmond et al. (2011) reported that only safety behavior may not contribute to safety performance directly, but very helpful to promote a safe working environment when workers participate in meeting and training related to safety. Recent research exploring the safe behavior noted that safety attitude, safety knowledge, and supporting workplace are the main indicators of safety behavior. The improvement in safety attitude and safety knowledge may result in the highest feasible proportion of safety behavior among the workers (Mohammadfam et al. 2017). The workers' safety behavior appears to be an important factor in the safety climate assessment tools, thus needs to be considered part of the safety climate in construction.

2.8.5 Safety Communication:

Generally, frequent communication and interaction with colleagues are mandatory channels to develop or improve social setup including organizational climate. The existing literature suggests that most of the researchers considered communication as a factor that constitutes the organizational climate. For instance, James and James (1989) viewed that organizational climate can be assessed considering the factors related to the individual and or workplace. Similarly, Siew (2015) considered Poor communication on health and safety (H&S) related issues as a major cause of incidents/accidents and recognized it as a key challenge to construction practitioners. The general organization's climate can be measured by considering the working environment which may include factors such as leadership, role, and communication (James and McIntyre, 1996). There have been a number of studies which concludes that effective safety communication is one of the safety climate factors which can be used to predict the safety performance of a specific organization (Zohar, 1980; Zohar and Luria, 2005; Pousette et al. 2008; Kines et al. 2011). When the organization encourages open communication on the safety-related issue, it spread a strong message on how safety is given values in that organization (Hofmann and Stetzer, 1998). Safety communication is not only referred to share information, but it is a channel to share ideas and views to help others to learn new things and to incorporate the innovative thought in the existing procedures. Jeffcott et al. (2006) emphasized the learning process to develop a safety culture. They suggested that the collection, analysis, and sharing of relevant data is very important to develop such a culture, where the workers don't hesitate to report their mistake or error. Workers normally share their mistake or error when they have full trust in the management, thus open and rich communication becomes a more important factor in organizational safety climate not only for safety performance but also to maintain the trust of their workers. Kines et al. (2011) Safety communication, therefore, should be effective and should be multiway, from management to employees, from employees to the management and among the employees. Similarly, Hale (2000) also emphasized the need for open communication in an organization to improve its safety performance. One of the other aspects which are related is the language barriers, which is more important in the construction industry due to its diversity. For instance, the Omani construction industry is highly populated (92%) by foreign workers (Umar and Egbu, 2018-a). These workers come from different Asian and African countries. These workers have a low education level and can only speak and understand their native languages. This situation results in communication barriers as discussed by Gittleman et al. (2010). Construction organizations, therefore, will have to assess the level of communication barriers first before they can further improve the safety communication in their organization. This discussion further leads that safety communication is one of the important dimensions of the safety climate and need to be considered in such assessments.

2.8.6 Safety Accountability and Justice:

It is considered an important factor that organizations maintain a fair and just system to deal with safety-related issues especially when the employees feel no fear to report errors and mistakes. Reason (1997) while discussing the safety culture, argued that in a mature safe working environment, the workers should be convinced to report the error to their supervisors. Similarly, it is very important the error and mistake either results in an accident or not needs to be dealt properly and the responsibility of such a situation should be fixed carefully as the blame can result in an obstacle in learning (Jeffcott et al. 2006). Similarly, the employees who act unsafely knowing well that his act is unsafe and the employees who act unsafely by mistake should not be considered for the same treatment (Weiner et al. 2008). This can be however challenging to differentiate among such unsafe acts. A just working environment, therefore, needs to be based on trust, but there has to be a clear line between acceptable and non-acceptable behavior. Organ (1997) defined the organizational citizenship behavior as a volunteer behavior which is very difficult to be recognized by organizations reward procedures, however, such behavior promotes the effective functioning of organizations. He further stated that the workers, who take actively the safety responsibility of themselves and others and participate in safety-related activities, display the organizational citizenship behavior. Kines et al. (2011) argued that worker's safety behavior and safety responsibility are positively influenced by the organization's rules and procedures which are applicable to safety matters. In other words, an effective just system for dealing with accidents and unsafe acts in an organization will promote safe behavior in workers and will encourage them to accept the responsibility of safety. Recently, Umar and Wamuziri (2016) in their research on the improvement of safety performance using safety climate factors discussed safety justice as an integral factor of constructions’ safety climate. They further considered that safety managers in construction organizations need to be accountable for safety expectations through their annual appraisal and performance evaluation. Such factors need to be considered further in their promotion to a higher position, pay rising or renewal of the contract. Overall, the organizations need to provide a fair system which should reflect the accountability and justice for safety. The investigations of the root causes of accidents are compulsory to ensure blame-free accountability. Similarly, the workers need to be rewarded for the exceptional safe act to promote safety to display a fair system. The review of the safety climate assessment tools discussed here reveals that safety accountability and safety justice were among the most common factors considered by several authors in their safety climate assessment tool, which trigger out that such factors need to be considered for the assessment of safety climate of construction organizations or the construction projects.

2.8.7 Supervisory Leadership:

The finding of the research conducted by Seo et al, (2004) shows that commitment form management or organization towards safety and support associated with safety from site supervisors are the two main factors used more frequently in the safety climate tools. The role of safety leadership was considered important in the safety performance of the workers by Hofmann and Morgeson (2004) and even observed from the literature on safety climate and safety culture that many researchers reference leadership directly as a key for improved safety. They further concluded that the leadership is further directly linked with other positives results in organization performance; for instance, it can improve and display an effective managerial commitment, production and can reduce absenteeism of workers. In reality, organization leaders have the responsibility to develop a mature culture within the organization that is effective to deliver a safe working environment. Many researchers stressed that supervisors and managers have the initial responsibility to reflect their commitment to safety and such commitment needs to be clearly seen by the workers. For instance, the supervisors and managers are required to take quick actions on the matters arising from the accident reports as it will be helpful in the development of worker's trust in the management (Mayer et al. 1995; Burns et al. 2006). The literature review suggests that employee's trust in management or organization plays a significant role in developing a safety culture (Umar and Wamuziri, 2016). The results of research conducted by Cox et al. (2006) show that the workers' distrust in management has a negative effect on the effectiveness of the safety culture. Trust in management or organization was viewed as an important factor by Kines et al. (2011) that they recommend it to be used in safety climate assessment tools. The safety climate tools developed by Seo et al. (2004) and the Center for Protection of Worker's Right (CPWR, 2017) used the supervisory leadership as a main or direct factor in their tool. Similarly, the tools developed by Kines et al. (2011) used it indirectly by linking it with trust in management. The research conducted by Umar and Egbu (2018) on safety climate factors in Oman considered the site supervisor role to be an integral part of the safety climate assessment tool. Overall, the discussion concluded that organizational performance is highly linked to supervisory or managerial leadership. The case with safety performance is the same as to be highly influenced by the supervisors' or managers' roles and leadership abilities.

2.8.8 Safety leadership:

It has been well established that without a clear definition of safety leadership, a misalignment between safety expectations may occur which can create a misappropriation towards safety efforts. This may adversely impact injury rates within the workplace due to ill-conceived safety leadership behaviors. The detailed definition of safety leadership may serve as a foundation for other industries such as mining, manufacturing or petrochemicals. To set the scene of leadership as it relates to safety, it was detailed from the work of Long (2013) that the board of directors sets the tone of leadership through governance, whilst the chief executive officer (CEO) personalizes the message with operational performance and the senior leadership team applies the strategy. This establishes a practical application in defining the behaviors that are evident in successful safety leaders within the construction environment.

The initial investigation of broader leadership studies as it pertains to safety was warranted through the research of Zanko and Dawson (2012). The conclusion from this research detailed that traditional occupational health and safety (OHS) have focused on policies and systems and there is a notable lack of research on OHS safety leadership behaviors. It was reported that OHS leadership is often lumped into the Human Resources (HR) field and further conceptual development is firmly needed. Safety leadership seems to be spoken of in the same breath as general leadership, without taking into account the nuances of safety.

A recent study into effective safety leadership defined the construct as ‘the process of defining the desired state, setting up the team to succeed and engaging in discretionary efforts that drive the safety value’ (Cooper, 2015). The details behind this definition were investigated and traced back to a website of a consulting company that offers services within the field of safety leadership. Their definition of safety leadership was neither research-based nor contextualized for the construction environment. A lack of a clear definition is further reflected through other research by Read et al. (2010). They detailed the importance of safety leadership when engaging the workforce, although no clear definition of what safety leadership means was provided. A national Australian competency framework towards safety leadership was detailed by Biggs et al. (2008) who defined a range of safety terms and approaches to safety leadership, however, failed to define safety leadership within the framework or as a stand-alone concept. There is a general sense that the definition of safety leadership is implied, innate or linked to broader leadership studies.

In a study undertaken by Lu and Yang (2010), the impact of safety leadership upon safety behavior was investigated within terminal operations. Safety leadership was defined within three main dimensions which included safety motivation, safety policy, and safety concern. It was detailed that safety leadership is a sub-system of organizational leadership, where visible leadership behaviors provide opportunities for safety issues and concerns to be discussed. The findings from Lu and Yang (2010) are based upon specific components of safety leadership being pooled under transformational and transactional leadership. Deeper elements of safety, culture and safety systems appear to be negated when considering the wider construct of safety leadership and its uniqueness from other leadership fields.

Research conducted by Wu, Chen, and Li (2008) investigated the impact that safety leadership has upon a company's safety climate and performance. Their definition and construct of safety leadership were established around safety caring, coaching and controlling. The inclusion of coaching has links within the field of relational leadership but was not detailed specifically towards safety. Their operational definition of safety leadership was borrowed from a safety leadership scale assessment, without an explanation of what safety leadership entails. Results from this study detailed that managers who demonstrate safety commitment positively influence safety performance with safety climate being the moderating component.

In a more recent meta-analytic review, safety leadership was explored under the guise of transformational and transactional leadership (Clarke, 2013). Results showed that transactional leadership is important in ensuring compliance with rules and regulations, whilst transformational leadership is associated with encouraging employee participation in safety. These elements were shown to have a mediating effect on safety culture. Further findings outlined suggestions for future theoretical development into the concept of safety leadership in order to explore leadership flexibility and its application within the safety domain.

The view that transactional safety leadership is warranted can be applied with some of the non-negotiable elements of safety. This pertains to the compliance of minimum standards of work which employees need to adhere to, sometimes colloquially called 'lifesaving rules'. The context of transactional safety leadership within the construction industry may raise some challenges due to this approach being a remnant of the less mature environment.

The application of transactional leadership within the construction industry may serve as a continuation of the status quo and a remnant of the less mature environment. This is echoed by the research of O'Dea and Flin (2001) that outlined leaders within the resources sector have a predilection towards directive leadership and even with knowledge of effective leadership behaviors, still choose to be directive. This, in turn, has an impact on motivating and controlling some of the more crucial aspects of safety. Recently safety leadership has been defined by Daniel (2015) considering the following key components as detailed in figure 2.26. Safety leadership has its unique variables established by the operating environment that it exists within and therefore differs from other leadership models. The implication of such variables allows a more viable discourse into the area of safety leadership which may minimize confusion and lack of clarity around the topic. The separation of how safety leadership differs from other disciplines is one of the key contributing factors. Future safety leadership programs can be cross-mapped for validity and linked to behaviors emanating from safety leadership definition and help reduce work-related incidents. The operating environment across the industries may slightly differ, although the safety leadership factors detailed in the definitions may still ring true. Safety leadership as an individual factor or as a combined factor with the supervisory leadership is expected to have a great influence on the safety climate of organizations.

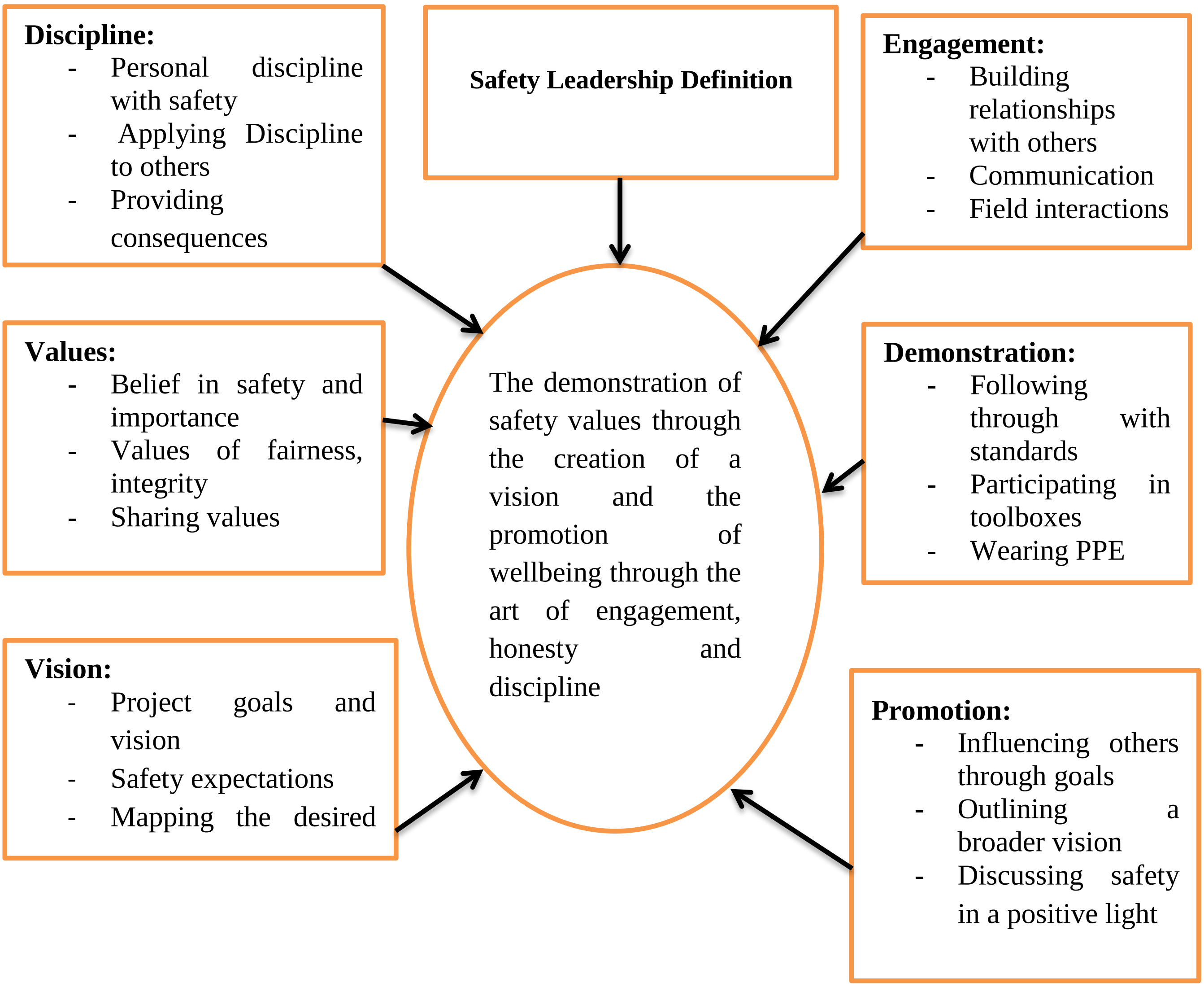


Figure 2. 25: Integral Components to the Definition of Safety Leadership (Daniel (2015)

2.9 Construction Organizations and Construction Workers in Oman:

Officially, in Oman, there are 100,000 registered construction organizations with a total workforce of 738,593 (OSC, 2016; Umar, 2016). These organizations are registered in different grades with the Chamber of Commerce and Industry. These grades are Excellent Grade, Grade One, and Grade Two and so on. The Oman Society of Contractors data shows that the total workforce in the Oman construction industry can be classified into two categories. One is Omani workers and the second category is of expatriates. The number of Omani as of 2016, stood at 54,753 (7.41%), consisting of 45,454 (6.56%) male and 9,299 (1.25%) female workers. Similarly, the total number of expatriate workers in the Omani construction industry was 683,840 (92.58%), dominated by male workers that stood at 682,485 (92.40%). There were only 1355 (0.18%) expatriate women working in the construction industry in Oman (OSC, 2016). Overall, grade one and above construction organizations in Oman employed a total of 439,867 (59.52%) of the construction workforce as shown in table 2.12. Similarly, the distribution of expatriate workers is presented in figure 2.27.

Table 2. 12: Distribution of Workforce in Construction Organizations (OSC, 2016)

Construction Organizations in Oman			
Type of Workforce	**Grade One and Above**	**Grade two and below**	**Total**
Omani Male	43,979	1,475	45,454
Omani Female	8,100	1,199	9,299
Expatriate Male	386,486	295,999	682,485
Expatriate Female	1,302	53	1,355
Total	**439,867**	**298,726**	**738,593**

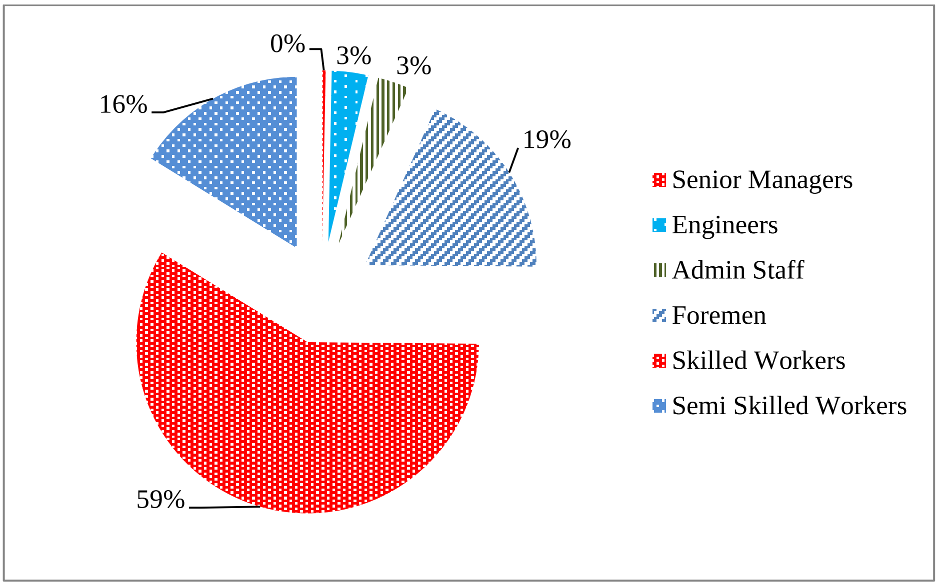


Figure 2. 26: Distribution of Expatriate Workers in Omani Construction Industry

Despite the regression in the oil price and considering the fact that not only the Omani economy is heavily reliant on the oil and gas export but also the entire Gulf region, the growth in the construction industry is evident. For instance, the number of registered international companies with the Tender Board of Oman (TBO) rose to 1092 in 2018, and this is recognizing the fact that the TBO only considers government tenders valued at 3 million Omani Rial (OMR) (1 OMR = US$ 2.60) or more. All these international companies were either registered as 'excellent grade' or 'first grade' (TBO, 2018). Generally, the ratio of the workforce and construction organizations which is 1:7, reflect that most of the construction organizations could be small and medium in size. It is somehow a universal fact that small and medium organizations have fewer financial and human resources at their disposal. Thus, under conditions of economic uncertainty, managers of small and medium organizations are reluctant to spend time and resources on problems that do not arise on a regular basis, and this would certainly include safety and health issues (Agumba and Haupt, 2012; MacEachen et al., 2010; Masi et al., 2014). In Canada, a small and medium organization is defined as a company with a staff of fewer than 100 employees, and such enterprises represent 98% of all businesses and employ 67% of the workforce in some parts of the country (Statistics Canada, 2013). Mendeloff et al (2006) noted that workplace fatal accidents are up to eight times more frequent in small and medium organizations. Similarly, the non-fatal accidents are as much as 50% more likely to occur in such organizations (Fabiano et al., 2004).

In relation to the safety performance, personal understanding, and interpretation of the workers which overall result in the behavior of the workers is considered much important. One of the factors which contribute to the overall behavior of the worker is basic education. Generally, a well-educated person is expected to have a more mature behavior. The total expatriates in Oman working in the private sectors in 2015 were 1,510,393 (32.36% of the total Omani population). The educational level of 1,136,840 (75.26%) of these expatriates was preparatory or below preparatory as shown in table 2.13. The educational level of the workers is one aspect which suggests that an educated worker may have a better safety performance than a non-educated worker; however, due to the nature of the construction works, only illiterate workers, who have no other choice, work here.

Table 2. 13: Distribution of Expatriate by Education Level in Private Sector in Oman (NCSI, 2015)

Educational Level	Male	Female	Total
Illiterate	19,360	1,965	21,325
Read and Write	364,830	44,838	409,668
Primary	124,033	18,786	142,819
Preparatory	502,683	60,345	563,028
Secondary	210,353	14,871	225,224
Diploma	41,168	4,457	45,625
University	64,328	8,634	72,962
Higher Diploma	3,689	543	4,232
Master Degree	3,417	569	3,986
PhD	696	204	900
Not Stated	14,886	5,738	20,624
Total	**1,349,443**	**160,950**	**1,510,393**

The next section describes the common research methods used in construction.

2.10 Summary:

This chapter aimed to provide a detailed literature review of the research topic. The literature review around the construction industry scope in general highlights the importance of the industry and the current situation of health and safety. It does suggest that there is much needed to be done to improve the safety performance in this industry. It is important that the causes of accidents in construction in Oman are to be investigated as this could help the organizations to develop strategies to curtail such causes and reduce the number of accidents. The literature review around the root causes of accidents in construction provided the key elements that need to be considered in the development of a tool that could be useful for the Omani construction industry. Similarly, the true cost of accidents is important to decision-makers. The literature review suggests that the cost of accidents in many countries is higher than the cost of prevention of accidents. Gulf region is one of the world hottest regions in terms of climatic conditions. Such environmental and climatic conditions affect worker performance, thus an important aspect of worker's safety and productivity. Specific guidelines for construction workers in Oman and other GCC region will be very useful, both for the construction workers and the construction organizations. The literature review around climatic and working conditions enabled to focus on the key aspects to develop such guidelines. Another associated important element in relation to safety and productivity is the workers' health. Different studies have shown that a healthier worker is productive and safer. The workers' physical health can be assessed easily through BMI, BP, and heartbeat. The robust Occupational Safety and Health Regulation and its enforcement in any country are keys to achieve the required level of safety performance. This research, therefore, considers the Occupational Safety and Health Regulations in Oman as one of the research objectives. While the existing regulations applicable in Oman were considered in this chapter, it is important to benchmark these regulations which some of the advanced countries and derive the gap for improvement. This has been done in a later chapter by comparing Omani regulations with the regulations applicable in the United States, Australia, United Kingdom, and South Africa. The literature review suggests that the concepts to improve safety performance in organizations have changed since 1980 when the focus has been shifted to organizational culture and climate. There have been a number of safety climate assessment tools developed and used in different countries and regions, however, the construction industry was in focus in few only. There has been no tool developed for the GCC region. This research, therefore, considers the development of a safety climate assessment tool for the GCC region as one of its objectives. Overall, the gaps in knowledge identified in this chapter are summarized in table 2.14.

Table 2. 14 Gaps in Knowlege

Research Component	**Gap in Knowledge**	**Link to Research Objectives**
Causes of Accidents in Construction in Oman and other GCC countries	Causes of accidents in construction Oman and other GCC countries are not properly investigated as there is no tool developed for construction organizations in the region to trace their accidents.	Objective I
Costs of Accidents in Construction in Oman	Accidents in construction result in a huge burden on the countries economies, however, the costs of accidents in Oman and other GCC countries are not truly evaluated to measure the impact on the economy of these countries.	Objective II
Heat Stress and its Impact on Construction Workers in Oman and other GCC countries	Different countries have developed guidelines to protect construction workers from heat stress considering their local environmental conditions. Arabian Gulf region is well known for its hot and humid climatic conditions, however, there are no specific guidelines that help to protect construction workers from heat stress.	Objective III
Occupational Safety and Health Regulations applicable to Construction Workers	Occupational safety and health regulations play a vital role to reduce the number of accidents at construction sites. Some countries such as the USA, UK, AUS, and SA have significantly improved their safety performance by revising and improving their regulations. It is therefore important to compare Oman's occupational safety and health regulations with the regulations of some advanced countries to identify rooms for improvement.	Objective IV
Construction Workers Health Factors and Body Pain in Oman	Globally it is an established fact that the construction worker's health factors affect their safety and productivity. Construction worker's health-associated factors have never been assessed in Oman. Such assessment help to make strategies on how to improve the health indicators if the workers are not in their healthy status.	Objective V and VI
Safety Climate and Safety Culture	The safety climate and safety culture approaches are adopted in many countries, however, most of the tools developed in this area focus on industries other than construction. Also, no tool specifically developed for the construction industry in the GCC region.	Objective VII

Since this research considered a number of objectives associated with the safety performance of construction organizations and different methods were adopted to achieve these objectives, the next chapter, therefore, explains the research methodologies adopted in each case.

Chapter 3: Research Methodology

3.1 Introduction:

This chapter describes the research methodology adopted for the different components of the research project. Considering the aim and objectives of the study, both the qualitative and quantitative research methods were employed. These two methods of research in relation to the research objectives are briefly explained in the first section followed by a detailed description of the methods and tools used in the study. This chapter further sheds light on the sampling process, data collections and data analysis. The research method used for each component of the research is discussed and explained with relevant justifications. To develop a theoretical relationship between the research methods and research methodology adopted in this research project, the next section explains common research methods used in construction followed by the research methodology adopted to achieve the research objectives of this research.

3.2 Research Methodology:

The research methodology adopted for the completion of this research project is commonly known as a mixed method which includes both the qualitative and quantitative data collection methods. Concisely, the difference between these two research methods is given below:

Quantitative research stresses quantification in data collection and examination. It takes a deductible way to the connection among theory and research and stress is kept on the confirmation of theories. The quantitative research method integrates the norms and practices of the natural scientific model and positivism. It views the social phenomenon as an outer objective truth (Cooper et al., 2006).

On the opposite side, a qualitative approach stresses on words and contexts despite quantification in data acquisition (Opdenakker, 2006). It focuses on an initial approach in the connection between hypothesis and research and the spotlight is settled on the development of speculations.

Umar and Egbu (2018), while discussing both the research methods, noted that the majority of the researchers prefer to incorporate both qualitative and qualitative methods, referred to as a combined research method. This was however not the only reason that both methods were adopted in carrying out this research. The main reason for using both the research methods in this project was the nature of the project and its objectives as stated in section 1.2.2 of chapter 1.

Briefly, the methodology used in this research is outlined as under:

a) Compilation of related knowledge

b) Development of data collection tools

c) Data collection

- Selection of appropriate sample size and respondents

- Defining the data collection process

d) Data Analysis

It was ensured that the research strategy is aligned with the research question. The involvement of the construction organizations and the construction workers in the research was therefore considered mandatory. For instance, construction accidents take place in construction projects or construction sites and involve construction workers. Thus to develop a tool that can be used to trace the root causes of accidents in construction, the data collection from the construction workers involved in the accidents is important. The reach such construction workers, the consent of the construction organizations for which they are working are mandatory. This research strategy applies to most of the research components of this research project including heat stress, workers' health profile, body pain, and the safety climate. As discussed in section 2.6 of chapter 2, there are approximately 100,000 construction organizations in Oman with an approximate number of construction workers of 725,000. Of course, all these organizations or workers can’t be involved in the study considering the scope and the time frame of the research project. The sample size for different research questions was therefore informed by the literature review. It was ensured that construction organizations are selected in a way that can provide the best representative sample of the industry. To achieve this, only the construction organizations registered in Grade one and above were considered for data collection. As discussed in section 1.4 of chapter 1 and section 2.9 of chapter 2, the selection of these organizations was also based on the fact Grade one and above organizations employed a significant number of workers in Oman. As a research strategy, the top construction organizations in Oman were targeted for data collection, however, this was subject to their willingness and cooperation. In some instances, as mentioned in section 3.3.1 of this chapter, a considerable number of organizations were contacted for cooperation in data collection, however, only a few agreed to cooperate. Apart from the selection of appropriate construction organizations, the research strategy as noted in section 1.3.2 of chapter 1 and 2.8.5 of chapter 2 required to select the respondents who can speak the languages which the researchers can speak to avoid the language barrier. Overall seven different camps were used to collect the data related to this research project. The data collection related to the causes of accidents and the heat stress mentioned in sections 3.3.1 and 3.3.3 was from one camp which has the workers of two different organizations. These organizations were executing a project on a joint venture basis. The data related to workers' health factors and body pain mentioned in section 3.3.5 of this chapter was collected from workers living in the third camp. The data collection related to the safety climate discussed in section 3.3.6 was done from the other four camps of four different organizations. Although the majority of the data used in this research is from Oman, the results are to be valid in other GCC countries due to the similarity of the construction industries in these countries. As discussed in section 2.2.1, the majority of the construction workers in the GCC construction industry are expatriates who belong to different Asian countries.

The required data for the research project was also collected through the internet using the search engine. Different keywords and time span was used to collect data from the internet. In some cases, data collected from the internet was filtered using different techniques such as google scholar citation, which are explained in more detail in section 3.3.6 (i) of this chapter. Similarly, to review the existing occupational safety and health regulation in Oman, and provide recommendations for revision and amendment, the existing regulation was review and compared with the occupational safety and health regulations applicable in the United States, United Kingdom, Australia, and South Africa. These countries were selected as a benchmark for the comparison of Omani regulation considering the fact as discussed in section 2.6 of chapter 2 that these countries have significantly improved the status of the occupational safety and health in the construction industry through their regulations. Thus in this situation, the research strategy is to review and compare the Omani regulation with the regulations applicable in the above-stated countries and find the gap for improvement. The important elements considered for comparison are discussed in section 3.3.4 of this chapter in more detail.

Overall, as a research strategy, a total of 89 interviews using four different sets of interview questions were conducted in the data collection stage. Each set of the interview has its own purpose. All the tools for data collection used in this research were initially tested on relatively small samples to determine the strengths and weaknesses of question format, wording, and order. Similarly, data from 152 respondents were collected using two sets of different questionnaires. Physical parameters such as Body Mass Index, blood pressure and heartbeat of 50 construction workers were measured. Briefly, the general schedule and description of different research activities incorporated in this research and mentioned in figure 3.3. The detailed research methods connected to different research objectives are explained separately in the following sections.

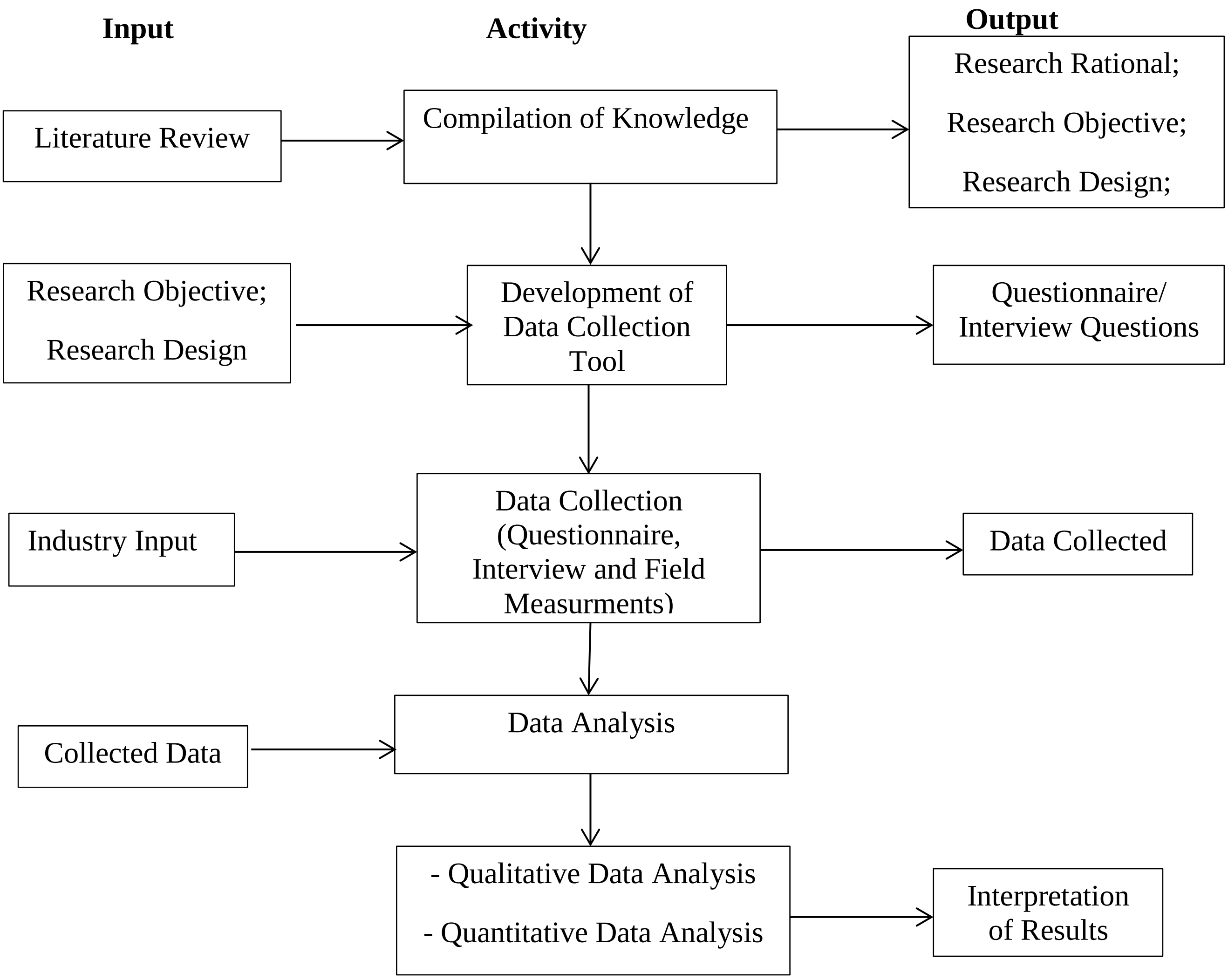


Figure 3. 1: Research Activities Diagram

3.2.1 Research Methods in Construction:

Generally, research methods can be initially classified as quantitative and qualitative research methods and both have some advantages and limitations which are discussed in later sections of this chapter. Both of the research methods are mainly different from each other in;

- Systematic objectives
- Questions types and postures
- Data collection technique
- Data production
- Flexibility

Researchers generally give more credit to the flexibility and regard this as the leading difference between the two methods. Overall, qualitative research methods are considered to be more flexible than quantitative research methods. The reason for this is that in the quantitative methods, such as using a structured questionnaire, the researcher needs to ask all the respondents the same questions in identical order. The answers of the respondents are recorded on a liker scale. Thus the participants have to choose their answers from limited categories provided on the questionnaire itself. The participants have no other choice than except selecting their choice provided with the question. This inflexibility of the quantitative research method, however, results in an advantage of this method which allows the researcher to arrive on a meaningful comparison between the respondents. With regard to the key differences in both research methods, table 3.1 is presented to illustrate them.

Table 3. 1: Key difference in Quantitative and Qualitative Research Methods

Description	Quantitative	Qualitative
General Framework	Attempt to pledge the hypothesis of a study Tools used are more rigid and tend to categorize the responses Adopt structure tools such as structured questionnaire / observation / experiments	Attempt to explore the study Tools are more flexible which provide the respondents to categorize their responses Adopt semi-structured methods, such as interviews / participant observation
Systematic Objectives	Measure differences Estimate causal connections Delineate attributes of a population	Outline differences Outline and describe connections Outline group standards
Question Structure	Closed ended questions	Open ended questions
Data Structure	Numerical	Textual
Flexibility in Research Design	Study design remains stable from starting to end Participant response to one question doesn’t change the sequence of the remaining questions in the survey Research design is based on the statistical assumptions and conditions	Some characteristics of the study are flexible, for example, changing the wording of the question so that the respondents understand it easily Participant response to one question may force the researcher to change the sequence of the questions Research design (data collection and questions) can be changed based on the results

The next sections describe the quantitative and qualitative research methods, while section 3.2.4 sheds light on the use of the semi-structured interview.

3.2.2 Quantitative research Method:

The quantitative research method can be defined as a research approach that stresses quantifications in data collection and analysis. This method of research involves a deductive approach to the connection between theory and research, in which the accent is placed on the testing of theories. This method of research further incorporates the practices and norms of the natural scientific model and positivism. In most of the quantitative research methods especially those applied in the social sciences use a questionnaire to collect the required data. Overall there could be 11 steps in the whole process of quantitative research starting from “theory” and ending on “writing finding/conclusion” (Bryman, 2016). The process of the quantitative research shown in figure 3.2 appears to be linear, but in reality, some of the steps can be skipped, as the researchers may change the actual process based on their own requirements. Generally, quantitative research methods provide ‘snapshots’ and so, are used to address questions such as what, how much, how many, etc.? It can be corrected that the data, and results, of this research methods, are instantaneous or cross-sectional. Qualitative research methods solicit to find out why things happen as they do; to determine the meanings which people attribute to events, processes, and structures. Many qualitative studies use data regarding people's perceptions to investigate aspects of their social world; others seek to ‘go deeper’ to address people's assumptions, prejudices and to find their impacts on behavior and organizational or project performance (Fellows and Liu, 2015). Research in construction is regarded as young or intermediate in maturity and in matching to the fieldwork context. Hence, accentuation of exploratory studies using qualitative methods, rather than hypothesis testing or quantitative methods that are appropriate for mature disciplines; is considered more appropriate to foster the development of construction knowledge (Fellows and Liu, 2015).

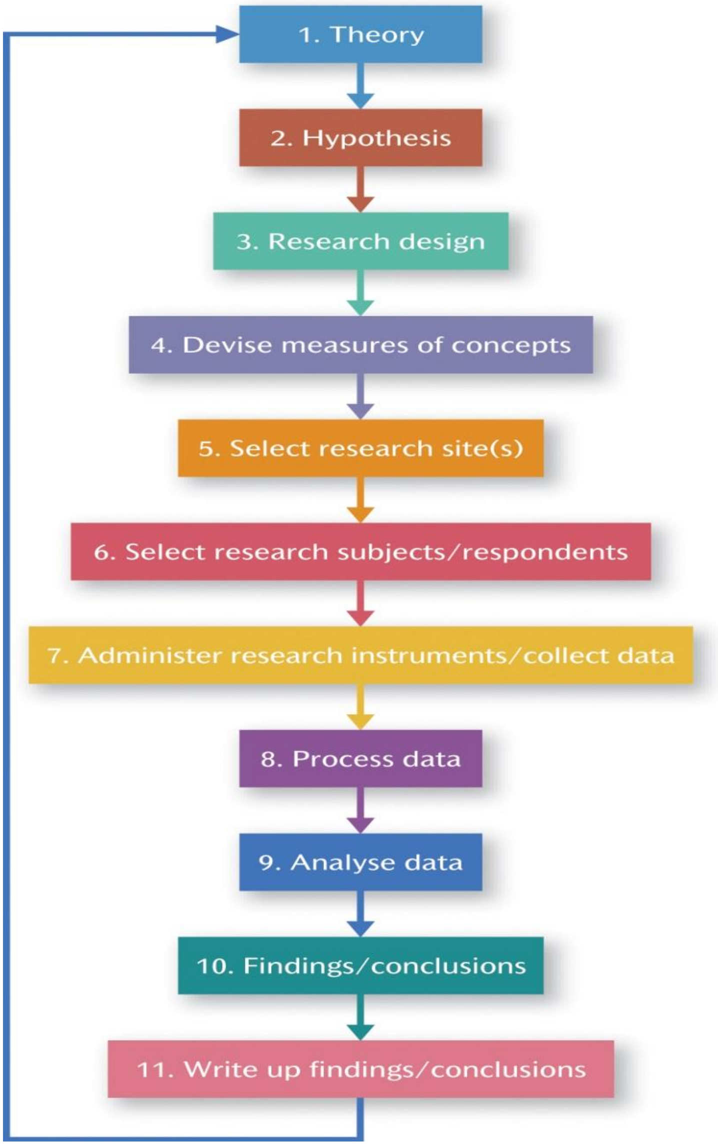


Figure 3. 2: The Process of Quantitative research (Bryman, 2015)

Since both the quantitative and qualitative research approaches are different from each other, the next section, therefore, explains the process of qualitative research.

3.2.3 Qualitative Research Method:

A qualitative research approach stresses on words and contexts despite quantification in data collection (Opdenakker, 2006). It stresses an introductory approach in the relationship between theory and research and focus is settled on the formation of theories. The process of the qualitative research guided by Bryman (2016) and commonly adopted is shown in figure 3.3. Amaratunga et al. (2002) stated that it is difficult to find an unambiguous and definitive statement that explains which method is the qualitative research in the built environment or in construction. This confusion is due to the fact that topic, theory, and methodology are normally interrelated in qualitative research. Similarly, Miles and Humberman (1994) suggest that qualitative research can be conducted through intense and prolonged contact with a field or life situation. Such situations can be normal in most cases which reflect the everyday life of individuals, groups, societies, and organizations. One of the common methods of qualitative research is the semi-structured interview which is explained in the next section.

Figure 3. 3: Process of Qualitative Research

3.2.4 Semi-Structured Interview:

One of the main methods in the qualitative research method is the use of a semi-structured interview. Bryman (2016) noted that the use of semi-structured interview methods enable the investigator to check the level of understanding that a participant has around a specific issue – generally in more detail than a paper questionnaire – and can be utilized as an effective tool of exploratory evaluation. Similarly, it can be helpful to understand how a participant thinks about a specific topic prior to using a secondary method such as respondent observation and deeper interviewing to collect a lager extent of information. Face-to-face interviews can also be useful to recognize participants whose perspectives may be investigated in more detail through the use of focus groups (Brannen, 2017). The method further allows asking the majority of the questions to respondents in a similar pattern. This makes the process simple for the researcher to repeat and replicate the interview. Overall, such a method of research approach is easy to standardize. Furthermore, it allows researchers to contact acceptable numbers of respondents comfortably and quickly and can collect reliable data (Cooper et al., 2006; Thurman, 2018). There are, however, some weaknesses and limitations in this approach. For instance, Bryman (2016) noted that such methods are time-consuming if the selected sample group is larger, the reason being that the researcher or their representative is required to be available at the time of the face-to-face interview. Similarly, Punch (2013) mentioned that the quality and value of the collected information are deeply dependent on the nature of the questions asked. The pattern of the questionnaire makes it difficult for the researcher to evaluate complicated issues and beliefs. Even where open-ended questions are utilized, the extent of the answers the participant can give turns out to be more restricted than with other qualitative approaches (Brannen, 2017; Cooper et al., 2006).

In reality, the nature and objectives of the research along with the nature of the data collection and analysis methods employed, determine whether the study may be classified as qualitative or quantitative. Given the opportunity, of course, mixed studies may be undertaken. As mixed methods studies employ two or more research techniques, qualitative and quantitative approaches may be employed to reduce or eliminate disadvantages of each individual approach while gaining the advantages of each, and of the combination – a multi-dimensional view of the subject, gained through synergy. Thus, mixed research methods may be used for entire studies (such as by investigating a topic from several, alternative paradigms or/and research methodologies) or for individual part(s) of a study (such as collecting quality performance data from archival records of defects, questionnaires administered to project participants and results of participant observation). The above discussion reveals that both the methods (quantitative and qualitative) have some merits and limitation, thus it is more beneficial to adopt both the approaches as a mixed research method.

The next section discusses the philosophical underpinning of the research.

3.2.5 Research Philosophy:

According to Holden and Lynch (2004) for every researcher, there are some fundamental questions that require important consideration from the researcher such as “What to research” and “How to conduct the research”. The center of these questions is, however, to answer the question is “Why research?”. Of course the research aim and objectives the set for this research answer the first question, however, it was the existing literature review that allowed to choose a research methodology. This enabled us to answer how to conduct the research which is deeper than just the practicalities but something more far-reaching, which is the philosophical solution that justifies the “Why research”. Machamer (2004) considered the “Philosophy of Science” as an area of study that explains the exact way in which epistemologies and ontologies influence the process and structure of social research. the three common reasons listed by Easterby-Smith et al. (2008) for the understanding of philosophical issues are; (i) it helps to clarify research design (research design deals with the methods by which data is collected and analyzed). (ii) The knowledge of philosophy helps to recognize the workability of designs and (iii) Having knowledge of philosophy also helps to identify and, perhaps, create designs that may be outside the researcher's previous experience. The knowledge of philosophy requires the researcher to make some core assumptions regarding two dimensions to the research including (i) the nature of science and (ii) the nature of the society (Holden and Lynch, 2004).

There are some parameters that describe beliefs, assumptions, perceptions, the nature of truth and reality and the knowledge of that reality. These parameters have a strong ability to influence the process in which the research is undertaken, from the beginning of the design through the conclusions. Kothari (2004) noted that the discussion and understanding of these aspects of the research which intend to approach harmony with nature and aim of the research and to ensure that the researcher's biases are identified, understood, exposed and minimized is known as the "Research Philosophy". Being an academic having several years of experience in Oman, Pakistan, and the UK have bestowed on the researcher both experience and ideas of how safety-related tools and issues for construction should be developed and improved. According to Holden and Lynch (2004), it is important to note that the philosophical understanding that the researcher chose helps to increase his/her confidence in the appropriateness of the methodology.

The aims of this research to develop guidelines and tools that can be used to improve safety performance in the construction sector in Oman and other GCC countries. To achieve the aim and objectives of a study, there are several methodologies open to the researcher for the collection of data. Gittins (1997), noted that choosing the appropriate research methodology is important, as it determines the research methods to be adopted in the research. When choosing an appropriate research methodology the two main factors to be considered important as noted by Remenyi et al. (1998). These factors are; (i) The specific research questions, and ii) the topic to be researched. While reviewing the research methods, Jobber (1991) argued that it is wrong to claim that one method is superior in abstract terms, as every method has its strengths and limitations. In this research, the researcher has chosen to lean towards positivism (quantitative methodology) as the most appropriate research philosophy. This research seeks to develop guidelines and tools that can be used to improve safety performance in Oman.

There are a number of research paradigms, which can be roughly categorized as either alternative paradigms (realism, interpretivism) or dominant paradigms (positivism)

(Saunders et al., 2007). The default paradigm for most scientific research is positivism and it assumes an ontological position, which is: there is a true reality that is discovered by means of rigorous, empirical and mostly quantitative study (Guba and Lincoln, 1994). The Positivists paradigm is not suited for this study for the fact that positivist researchers detach themselves from the research problem and are, hence, not able to deeply and subjectively interact with all the respondents as it is a key requirement in this study to fully and better understand the research problem being investigated (Yin, 1994). All the uniqueness of the organizational structure, construction projects, culture, and human resource motivation need careful consideration for a better understanding of their influence on the safety performance of an organization or a project. Also, the research problem requires an investigation into the organizational, managerial, and supervisory perception of the safety climate that is common in the construction industry in Oman. This is important that as the organizations, people and technologies involved in construction management are undergoing constant changes, making it impossible to repeat the study under the same circumstances as positivism requires repeatability of studies. This is, however, not possible in this instance. Taking into consideration these important facts, positivism as a scientific research paradigm is therefore deemed not suitable for this study.

Similarly, this research adopted an interpretive approach which is the research philosophy for this study. This is because the interpretive approach allows for an in-depth perusal of the details of the situation and an attempt to understand the reality or perhaps a reality that influenced that situation. From the interpretive view, it is important to explore the subjective meanings that motivate people's actions, for a better understanding of their actions. Furthermore, for this study, the research strategy applied is the descriptive approach since the study aims to collate first-hand information from the multiple projects and its team in different construction organizations. Although the epistemological position of this research leans towards interpretivism and deploys the qualitative strategy, combining it with some aspects of quantitative strategy from positivism provided a richer outcome, as adopting just one paradigm may offer a limited window to the research (Mingers, 1997). This enabled the study to understand and analyze some quantifiable views, which are also important objectives of this study.

For this reason, the multi-methodology approach was found most suited for this study and was

Therefore adopted. Multi-methodology is perhaps relatively emerging as a popular research methodology where more than one research methodology is combined in whole or part within an intervention. Although Fellows and Liu (2008) emphasized that the established practice is that a research study must identify with a paradigm, multi methodology approach is very attractive and possibly produces the best results in social science researches, which includes the complex construction industry where qualitative and quantitative approaches should be seen and applied complementarily rather than competitively and mutually exclusively (Dainty and Murray, 2007). Summarily, although this research will adopt a multi-methodological pluralism approach, greater emphasis will be placed on the qualitative strategy to the end that the blend will yield an improved result in this research study on the improvement of safety performance in construction organizations in Oman. Similarly, the proposed epistemological philosophical position of the study leans towards “Interpretivism”, whilst the ontological position leans towards “Constructivism” (Creswell, 2014). In terms of the axiological philosophical position, a stance leaning towards “Value -Free” (Creswell, 2014; Saunders et al., 2012) was followed. In the same vein, the methodological approach is pluralistic or multi-methodological. The nature of the study demands that both quantitative and qualitative approaches are employed.

The next sections describe the research approaches adopted to achieve the different objectives set for this research. The first section describes the research method used for the development of a model to trace the root causes of accidents in construction.

3.3 Research Methods:

3.3.1 Research Method (Research Objective No. 1: Causes of Accidents):

As discussed in chapter 2 with some details that knowing the root causes of accidents can help construction organizations in preventing accidents in the future through appropriate risk mitigation measures and by addressing the weak areas associated with accidents (Umar and Egbu, 2018). As discussed in section 2.3 of chapter 2, construction researchers have proposed several accident causation models and root causes. The majority of them are complex and difficult to use and adopt. This research, therefore, aims to develop a simple model for tracing the root causes of accidents in the construction which can be easily adopted by the construction organizations. The methodology adopted for this research is to review and establish four main root causes of accidents in Construction from existing literature. These four main root causes of accidents are listed in section 2.3 of chapter 2.

Each of these factors is then supported by a number of statements as noted in table 4.1 of chapter 4 that effetely reflect the factor. This was done by partnering with the leading construction organizations that are willing to cooperate and satisfy the condition stated in section 3.2 of this chapter. The model developed was the first review by the health and safety expert of the partner organizations and then apply on the accidents that happened in these organizations to ensure that the model is serving the purpose and the results can be interpreted.

To complete this part of the project, the partner construction organizations were requested to provide their accident statistics of a specific project on a standards format which includes date and time along with a brief report of each accident. For the type of accidents, the same classification of accidents was used as described by Umar and Egbu (2018). Briefly, this classification is shown in table 3.2.

Table 3. 2: Classification of Accidents

Alternate Work Injury (AWI)	**First Aid Injury (FAI)**	**Loss Time Injury (LTI)**	**Medical Treatment Injury (MTI)**	**Property / Equipment Damage**
A work injury that results in the injured person being able to perform only restricted (light) duties in the original workplace on the first scheduled workday or shift (or any subsequent workday or shift) on the day after the incident.	A work injury that requires first aid treatment, including observations, TT (Tetanus Toxoid) injections, non-prescription drugs, pain killers, examination, oral rehydration, minor dressings even if carried out in the hospital.	A work injury or disease resulting in a fatality, permanent disability or time lost from work of one or more complete workdays or shifts, following the fourth day or shift of the incident. Fatalities causes from suicide or natural causes are excluded.	A work injury that requires treatment other than the first aid at a hospital or other medical facility.	These are incidents resulting from workplace activities that caused damage to property or equipment only.

In this research method, a purposive sample method as described by Bryman (2016) was used to select the construction organization. Overall there are 100,000 construction organizations registered in Oman as contractors that employ more than 700,000 construction workers (Umar and Wamuziri, 2016). This gives an overall ratio of 1:7 (organization: workforce), however, only 6,000 (out of 100,000) companies are grade one and above, while remaining organizations are registered in the lower category. The 6,000 companies employed a total of 320,000 workforces (1:53), on the other side the 94,000 grade II and below organizations have a total number of employees of 389,000 (1:4) (OSC, 2015). This clearly indicates that grade II and below construction organizations in Oman are comparatively very small in size. Surely, an organization with a total of seven employees will never maintain any record of their accidents, therefore calculating the sample size on the total population (N = 100,000) will not be helpful. Similarly, the Tender Board of Oman statistics shows that there were only 401 companies (out of 2034) registered as an excellent grade as shown in table 3.3 (TBO, 2018). It is important to note that the Tender Board of Oman only deals with the government tenders which are valued at 3 million Omani Rial (OMR) (1 OMR = US$2.60) or more. Statically, a sample size (n) can be determined using equation 3.1.

Table 3. 3: Contractors Registered with Tender Board of Oman (TBO, 2018)

S.No.	Grade of Company registered in the construction work category	Number of Companies Registered
1	Excellent Grade	401
2	First Grade	282
3	Second Grade	286
4	Third Grade	293
5	Fourth Grade	772
	Total:	**2,034**

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)} \qquad \text{............Equation 3.1}$$

N = Population Size
e = Margin of error
z = z-score

"e" which is the margin of error is noted in percentage, for the purpose of calculation this is converted into decimal form (for example, if the margin of error is considered as 3%, then in equation 3.1 it will be used as 0.03).

The z-score is the number of standard deviations a given proportion is away from the mean. The z-score can be obtained from table 3.4.

Table 3. 4: Z-Score for Different Confidence Level

Required Confidence Percentage	**z-score**
80.0%	1.28
85.0%	1.44
90.0%	1.65
95.0%	1.96
99.0%	2.58

Similarly, a more simple formula for sample calculation was suggested by Yamane (1967) as shown in equation 3.2.

$$n = \frac{N}{1 + N(e)^2}$$ …………Equation 3.2

Where;

n = size of the sample
N = size of population
e = precision level

For instance, equation 3.2 is used to determine a sample size (n) considering the population size (N) of 100,000, and the level of precision (e) as 5%, thus the value of sample size (n) will be 399 companies. However, since the purposive sampling best fit to sever the research objective, the criteria adopted for sampling in this part was to ask the top five construction organizations registered as grade I and above. The accident data were only collected from the organizations which were agreed for cooperation in this research. The construction organizations were assured of the confidentiality and anonymity of their participation that their provided data will be kept strictly confidential. The construction organizations were further assured that only the researcher and supervisor will have direct access to the information which they will provide for research purposes. A total of 623 accident data was received from two organizations jointly executing a highway project with an estimated cost of US $ 305.90 Million. Both of these organizations were registered as general contractors in Oman. The results, analysis, and discussion on the tracing model and the root causes of accidents are made in sections 4.2 and 4.7.1 of chapter 4.

The research method to achieve the research objective No. 2 which is related to the costs of accidents in construction is explained in the next section.

3.3.2 Research Method (Research Objective No. 2: Costs of Accident in Construction):

The literature review presented in chapter 2 on the costs of accidents suggests that an awareness of the cost of accidents in construction will help construction organizations and its decision-makers to increase the spending on occupational safety and health-related matters to avoid accidents. The owners of small organizations are, however, reluctant to spend time and resources on problems that do not arise on a regular basis (Agumba and Haupt, 2012; MacEachen et al., 2010). Accidents in construction are one of the problems which don't occur frequently, however, if it happens then the cost associated with it is huge in most cases. Umar and Egbu (2018) while discussing the accidents in construction noted that construction workers are 3 ~ 4 times more likely than other workers to die from accidents at the workplace. In developing countries, the hazards linked with construction work maybe three to six times more. Accidents include not only direct physical injury to persons or damage to property but also short and long term effects or incidents due to other exposures on sites that affect the workers' health and physical well-being. Thus the costs of accidents (direct and indirect) can be substantial. Overall, the estimation of the cost of accidents is a complex issue and in most cases, it is very difficult to come over an agreement that could translate the cost of an accident into financial value. Umar (2016) in his research on the cost of accidents in the construction industry in Oman concluded that statistical data of construction accidents and their associated costs are not available in Oman, thus it is very difficult to estimate a realistic cost of accidents in construction in Oman. He, however, also concluded that a better understanding of the financial benefits of improved safety performance will encourage construction organizations in Oman to enhance their safety performance. Similarly, accidents in construction as mentioned in table

3.1 are different from each other not only in their nature but also in their implication, thus may have different financial losses.

Even if all these accidents are considered, the total number of these accidents will be required to estimate their costs apart from what are the average costs of each of these accidents. Umar et al. (2018) while discussing the occupational safety and health regulations in Oman concluded that the construction industry in Oman is not mature as of that in the USA and UK. They further noted that the situation around safety and health, and the availability of related data, is, however, more or less the same in all Gulf Cooperation Council (GCC) countries. Earlier Umar and Wamuziri (2016) in their research entitled “A Review of Construction Safety, Challenges, and Opportunities - Oman Perspective” stressed on the establishment of an independent organization in Oman on a similar pattern of Health and Safety Executive (HSE) in the UK or Occupational Safety and Health Administration (OSHA) in the USA. They recommended that this organization should work with all stakeholders, develop and implement occupational safety and health regulations and improve awareness on occupational safety and health by collecting, analyzing and communicating the related data and its results.

Since the overall purpose of this research objective (to estimate the costs of an accident in GCC construction) is to give awareness on the cost of accidents in GCC countries which will be helpful to increase the awareness on the importance of spending on safety, thus the calculation of the costs of accidents was kept limited to a rough estimate. The methods adopted to accomplish this estimate are shown in figure 3.4. As a first research strategy, private medical insurance companies in Oman which provide medical and accident insurance to the construction workers were asked for cooperation and data sharing so that the costs of accidents in the Omani construction industry can be established. These insurance companies, however, refused to share such data due to several reasons. The second research approach was to ask the construction organizations for such data; however, they also refused to share such information. As discussed in section 2.2.3, one of the main reasons for not sharing this data, was the reputation of the construction originations. Finally, the costs of accidents in Oman and other GCC countries were established considering the average costs of accidents in the USA, UK, AUS, and SA. The average values of the costs of accidents from the USA, UK, AUS, and SA were considered comparable with the direct costs of accidents in GCC countries. The costs of accidents in the USA, UK, AUS, and SA were obtained from different reliable sources. For instance, the costs of accidents in the

USA were obtained from different studies conducted by the Center to Protect Workers' Right (CPWR) and the National Institute of Occupational Safety and Health (NIOSH). The research study conducted by Haupt and Pillay (2016) on the costs of accidents was used to acquire the costs of an accident in SA. Similarly, the statistics related to the costs of accidents in the UK were obtained from different studies available on the Health and Safety Executive (HSE) website. Safe Work Australia online resources which have the data related to the costs of accidents in Australia were also used to establish the costs of an accident. Three countries from GCC including Oman, Qatar, and Saudi Arabia were considered to estimate the indirect costs of the accident. Data related to indirect costs of accidents (costs of compensation for injuries) was obtained from Public Authority of Social Insurance (PASI) in Oman using its official annual reports which are publically available on their website. Similarly, data related to the indirect costs of accidents in Saudi Arabia was obtained from the General Organization of Social Insurance (GOSI). The statistical data associated with the indirect costs of accidents in Qatar was extracted from the General Retirement and Social Insurance Authority (GRSIA). As a rule, the Public Authority of Social Insurance (PASI) only registers Omani citizens into their insurance system who working in private sectors. This rule is also applicable in all other GCC countries. Here it is important to note that there are only 8% Omani citizens working in the construction industry (Umar, 2016). The situation related to the employment of Saudi Qatari nationals in construction is not much different from Oman. Data related to the workforce in the construction industry in Oman was obtained from the Oman Society of Contractors website. Similar sources were used for Saudi Arabia and Qatar to acquire the relevant data. The costs of accidents in the selected countries were also calculated based on the cost of the projects and the average value of the costs of the accidents in the construction industry reported in section 2.4. The construction project data associated with the selected three countries was obtained from different reliable sources mentioned in the next chapter. The relationship between direct and indirect costs developed by Haupt and Pillay (2016) was used to determine the total costs of the accidents in selected GCC countries. The results, analysis and discussion on the costs of accidents in Oman, Qatar and Saudi Arabia construction industries are provided in sections 4.3 and 4.7.2 of chapter 4.

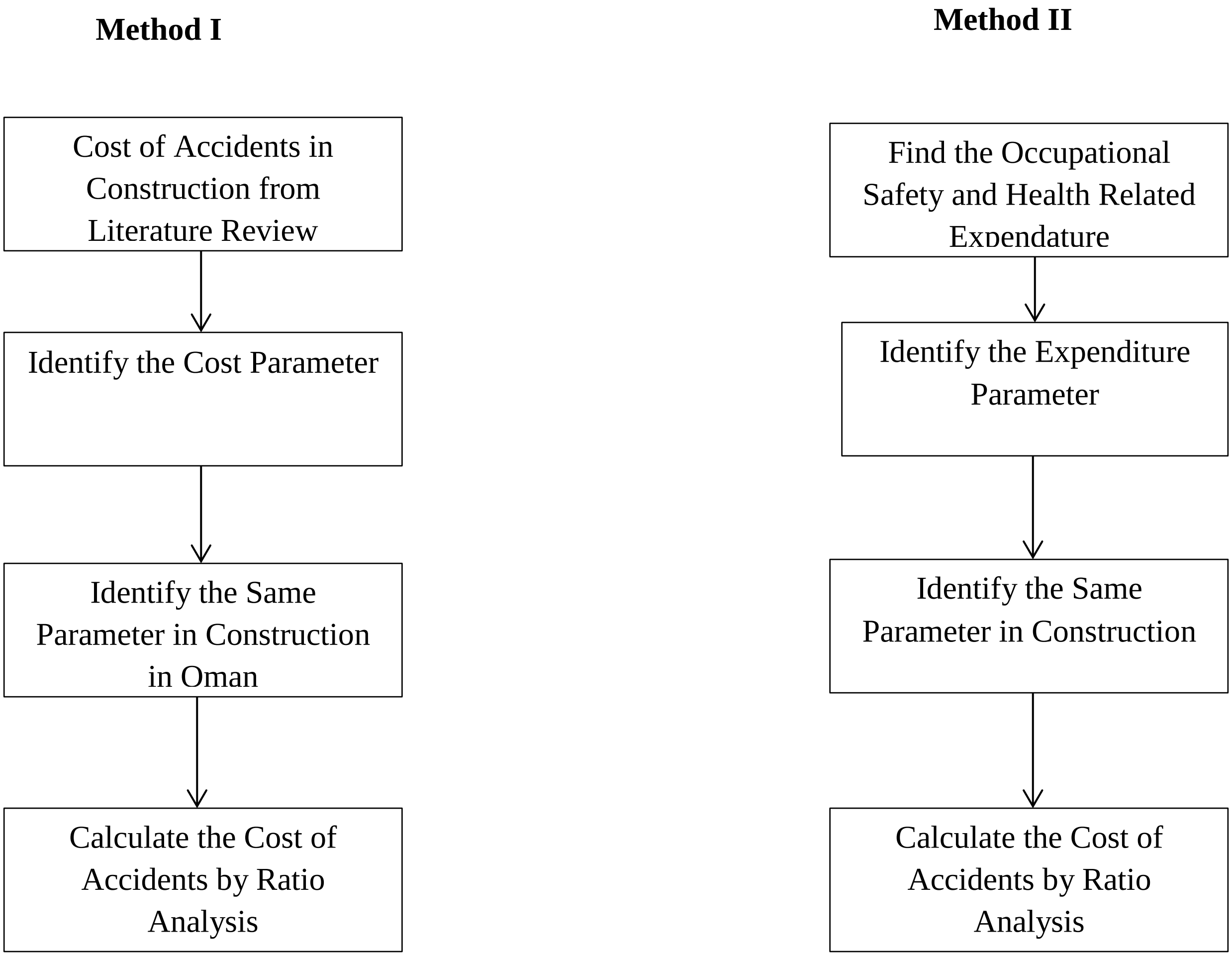


Figure 3. 4: Methods for Cost of Accidents

The next section explains the research methodology adopted for the research objective No.3 which is related to the heat stress.

3.3.3 Research Method (Research Objective No. 3: Heat Stress):

As discussed in section 2.5 of the literature review chapter (chapter 2), many researchers have established that extreme heat stress has a deep impact on physiological reactions, which results in occupational injuries and deaths. Oman as one of the gulf country is very famous for its hot climatic conditions. Government data reveals that the temperature reaches to more than 40° C in summer in Oman as shown in figure 3.5, however other sources reported more than this. For instance, a report published in a daily newspaper on 22 January 2017, quoting a reference from World Meteorological Organization, stated that 2016 was the hottest on record where the temperature reached 50° C (MD, 2016). Similarly, a report published in a daily newspaper 'Times of Oman' on 10 August 2015, reported the temperature at 48°C (TOM, 2015).

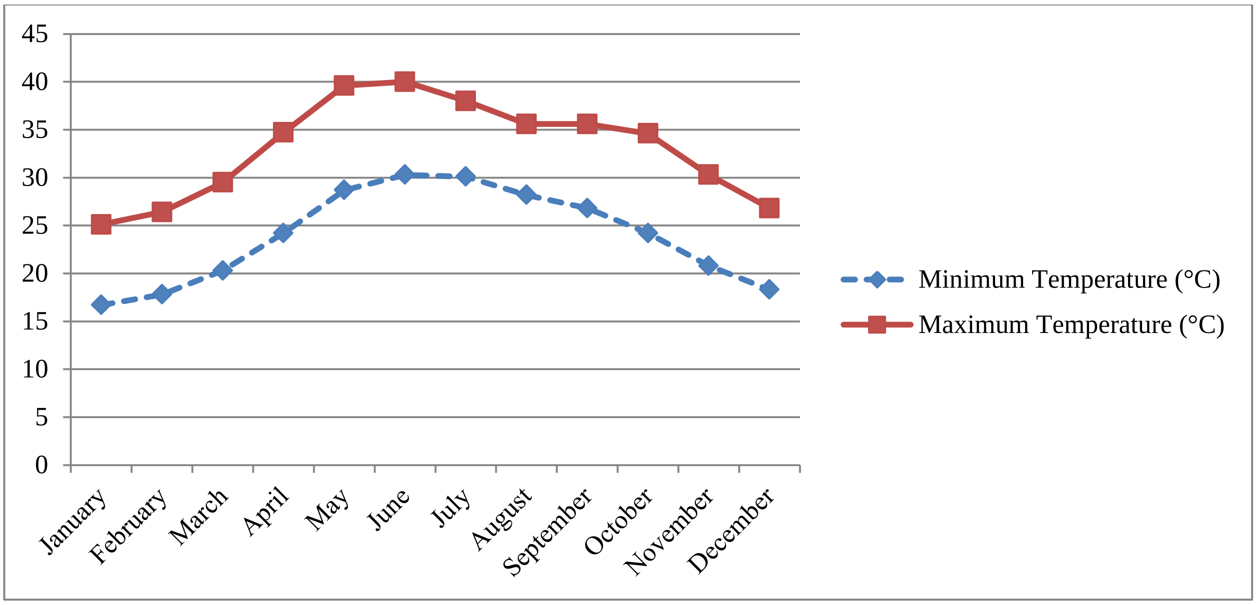


Figure 3. 5: Annual Temperature in Oman (DGM, 2018)

Considering the hot and humid climatic conditions of Oman and other GCC countries, it is important to know the impact of the climatic condition on the accidents in construction projects. This was done by analyzing the trend of accidents in a construction project in which the time and date (month) of the accidents were considered. To know the impact of the heat stress and develop guidelines to protect workers from the heat stress, semi-structured interviews were held with a number of workers mentioned in section 3.3.3 (ii) of this chapter. The physical parameter such as body mass index and blood pressure of these workers were also measured to effectively understand the situation. Sections 3.3.3 (i), 3.3.3 (ii) and 3.3.3 (iii) further expand the discussion of the research approaches adopted in different stages.

3.3.3 (i) Stage I:

In stage I, the accident data collected in section 3.3.2 (research objective 2) was analyzed to establish the trend considering the time and day of the accidents. This was done to see if there were accidents which took place in a specific time of the day and are there any relationship with the temperate or lunchtime. This investigation is aligned with the facts revealed in different studies which show that injuries at work increase when the temperature at the workplace rises (Xiang et al., 2014). A study conducted in Spain concluded that when workers eat, and drink in the morning break and at lunchtime can increase the chances of committing an accident and the severity of such accidents could be more (López et al. 2008). Similarly, a study carried out in Australian, shows that the number of accidents was comparatively more in the mornings than the accidents in the afternoons (Wigglesworth, 2006). Literature review somehow suggests that there is a specific time which results in more severe accidents however this time is different in a different region. Thus this investigation, if establish the time and day of more severe accidents, may be helpful for construction organizations in Oman to develop strategies on how to effectively control or reduce the accidents in that time and day.

The research method used in stage II is explained in the next sub-section.

3.3.3 (ii) Stage II:

A sample of 20 workers involved in these accidents was selected for a face to face interview. The sample was selected in a way to avoid the language barrier, thus the workers who were able to communicate in local languages such as Urdu, Punjabi, Hindi, and Pushto were selected. These were the languages that the researcher can speak and understand. Mason (2010) also in his research entitled “Sample Size and Saturation in Ph.D. Studies Using Qualitative Interviews” reported the result of five hundred and sixty studies and noted that the most common size of the sample in these studies was 20. The purpose of this interview is to get appropriate information on what caused the accident in which they were involved. For example, human factors or errors are one of the main contributors towards accidents; for instance, if an accident is caused by defective equipment or mishandling of materials, thus the main argument is why the defective equipment was available on the site or why the workers were allowed to use this defective equipment. A similar argument also applied to the accidents caused by materials. There could be several reasons for human factors, which may also include heat stress due to the geographic condition of the project. Workers were also asked about their sleeping habits and overtime preferences. The information provided by workers through this interview will be helpful to develop guidelines for protecting workers from heat stress in Oman. The selected workers were briefed about the purpose of the interview to reduce any pressure they may have and to allow them to share the accurate information. They were brief that they are allowed to withdraw at any time of the interview process. Written consent was obtained prior to the start of the interview. The questions were asked from workers during the face to face interview are;

1. Part of this study is to compare your Body Mass Index (BMI) with your age. Therefore, could you please kindly let me know your age in years?

2. I have been informed that you were part of an accident at work.

(i) Could you please kindly summarize the situation on the day when the accident happened? Please give me a brief summary of the accident you were involved in?

(ii) What was the main reason behind this accident? You have four options to choose one.

a) A mistake from you or your co-worker.

b) Machine or equipment

c) Type of work

d) Climatic or environmental

(iii) Were you tired on that day? You have three options to choose one.

a) Yes

b) No

c) I don't recall

(iv) How was the climatic condition at the time of the accident? You have two options to choose one.

a) The climatic condition was good at the time of the accident (the weather was clear and pleasant).

b) The climatic condition was good at the time of the accident (the weather was not clear and was not pleasant).

(v) Is it (climatic condition) was very hot? You have two options to choose one.

a) Yes

b) No

3. Normally we have a very high temperature in summer which results in sweat and exhaust the body energy.

(i) How do you protect yourself from excessive heat in summer?

(ii) Do you use any method to keep yourself less affected by sun heat?

4. Mostly employees in different sectors like to have additional working hours so that they can increase their earning.

(i) What is your thought on overtime?

(ii) Do you like to have overtime regularly?

5. What would be your preferred time to work for overtime?

6. Could you please let me know that as an overage for how many hours do you normally sleep?

7. As per government rule, workers must not work at construction sites or in open and elevated areas from 12:30 pm to 3:30 pm during the months of June, July and August. Is there are any factors that do not allow you to take this break?

8. Do you have any suggestion (s) on what needs to be done to protect construction workers from heat stress in Oman?

The research method which was used for field measurements such as Body Mass Index and blood pressure are covered in stage III and discussed in the next sub-section.

3.3.3 (ii) Stage III:

Stage III of this research includes the field measurements of Body Mass Index and blood pressure of the same construction workers who were interviewed in stage II to see that they are physically fit. For instance, the accidents may happen due to human error and possibly the worker may under different stresses including heat stress; however, several health conditions such as body blood pressure, heartbeat and body temperature can be directly linked to individual body parameters. An overweight worker could be more affected by heat stress compared to a normal weight worker. A Body Mass Index measurement is used to determine if an adult is at a healthy weight for their height. An individual BMI is calculated by dividing their weight in Kg by the square of their height in m^2. The BMI values from 18.5 to 25 are considered as normal (WHO, 2017). For example, an adult who is 17.5 m tall and weighs 70 kg will have a BMI of 22.9, which is in the normal healthy range. The literature review further suggests that high blood pressure is regarded as the main cause of hypertension (Daskalopoulou et al., 2015). Similarly, Poulter et al. (2015) reported that if a person is having blood pressure greater than or equal to 140 mmHg systolic blood pressure (SBP) or greater than or equal to 90 mmHg diastolic blood pressure (DBP) is to be classified hypertension. The finding of Carey and Whelton (2018) classified hypertension as a major cause of death and disability around the world. Overall the blood pressure can directly affect the physical abilities of a human, thus such workers are more open to accidents (Beevers and MacGregor, 1999).

The literature review in chapter 2 establishes that Body Mass Index and Blood Pressure were the common factors used in the determinacy of workers' health profile. Yi and Chan (2017) used both the parameters to study the effects of heat stress on construction labor productivity in Hong Kong considering a sample size of 30 rebar workers. The sample selected by Zhao et al. (2018) for the Impacts of cooling intervention on the heat strain attenuation of construction workers was fourteen. Similarly, 12 participants were selected by Aryal et al. (2017) for the monitoring of fatigue in construction workers using physiological measurements.

The workers were informed about the purpose of these measurements and they were insured that the collected data will only be used for this research and will not be shared with any third party including their employer. Written consent was obtained from workers before starting the measurement. The participants were brief that they are allowed to withdraw at any time of the interview process. For the calculation of Body Mass Index, the height (in meter) and the weight (in Kg) of each participant were measured. Equation No.3.3 was used to calculate the Body Mass Index from the measured height and weight.

$BMI = \frac{W}{H^2}$ …………………Equation 3.3

Where;

BMI = Body Mass Index

W = Weight in Kg

H = Height in meter

The resting blood pressure considering the Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) of the participants was measured with the help of a sphygmomanometer under the supervision of a qualified medical practitioner. The average of two readings was considered and used in further analysis. The results, analysis, and discussion on the heat stress are provided in sections 4.4 and 4.7.3 of chapter 4. The guidelines to protect the construction workers from the heat stress are presented in 4.7.4.

The research method adopted to achieve the research objective No. 4, which is associated with the Occupational Safety and Health Regulations in explained in the next section.

3.3.4 Research Method (Research Objective No. 4: Occupational Safety and Health Regulations):

One of the key elements identified through the literature review indicates that effective occupational safety and health regulations and their implementation are some of the main factors in achieving improved safety performance. The aim of this review is to offer some basic understanding of the Occupational Safety and Health regulations applicable to both employees and employers in GCC countries and suggest areas for improvement. Although are five different countries in GCC, however, they are not much different in relation to occupational safety and health. For this part of the research, Oman was considered to be more suitable compared to other GCC countries. A qualitative research approach as described in figure 2.2.6 of chapter 2 was considered. The review covers the existing literature on occupational safety and health regulations in Oman with the following key aspect.

- A brief comparison of a GCC member country's 'Occupational Safety and Health regulations' with USA, UK, Australia (AUS) and South Africa (SA) regulations. As discussed in section 2.6 and 3.2, these countries have significantly improved their safety performance with the help of up to date and robust occupational safety and health regulation. The literature review suggests fall protection; hazard communication standard related to chemicals; scaffolding; respiratory protection; control of hazardous energy; ladders; powered industrial trucks; training requirements; machinery and machine guarding; and eye and face protection are the important elements which could cause the accidents in construction. Effective regulations, standards or guidelines covering these elements could be helpful in reducing such accidents. For this comparative study, Oman's regulations were selected from GCC side and a comparison of the regulations, standards, and guidelines around (i) fall protection, (ii) hazard communication standard related to chemicals and (iii) scaffolding was made with USA, UK, AUS, and SA.

- Review of the rectified and pending International Labor Organization (ILO) Conventions.
- Recommendation for improvement.

The results, analysis, and discussion related to occupational safety and health regulation are presented in section 4.5 of chapter 5.

The next section explains the research method adopted to accomplish the research objective related to worker's health factors and body pain.

3.3.5 Research Method (Research Objective No. 5 and 6: Health Factors and Body Pain):

The literature review on occupational safety reveals that there have been several studies which have concluded that physical health factors such as elevated blood pressure, weight and sleeping habit of workers have a direct impact on safety outcomes (Beevers and MacGregor, 1999; Rees et al., 2013; Dua et al., 2014; Yi and Chan, 2016). The purpose of this part of the research was to determine the construction workers' health profile including Body Mass Index (BMI), blood pressure, heart rate and to assess their musculoskeletal pain considering pain experience, pain treatment, and its impacts on daily routine life. Data from 30 volunteer construction workers working in a construction organization registered as an excellent grade in Oman was collected. The project on which these workers were involved was a multi-story hotel (building) project. The workers were first briefed about the purpose of this research and were ensured that the information which they will provide will not be shared with their employer or any other organization. They were informed that all the collected data will be coded and will remain anonymous. All the information which will be collected through interview and questionnaire will be kept in a locked cupboard to which only the researcher and his supervisor has access. Written consent was obtained before the data collection. The data collection process was completed in two stages. Stage one includes the physical test and a face to face interview. Stage two is related to the musculoskeletal pain of workers, in which a structured questionnaire was used to assess workers' recognized pain problems. In part one of the data collection, the workers' individual characteristics and work associated factors such as age; sleeping habits, nationality, working experience in the construction industry and smoking habit were obtained in a semi-structured interview. The interview questions for face to face interview were;

i) Could you please kindly let me know your age or year of birth?

ii) How many hours do you normally sleep in the day?

iii) Is it possible to tell me about your nationality or ethnicity?

iv) How many years' experience do you have in the construction industry?

v) Do you smoke? If yes, how many cigarettes do you normally take in a week? Do you smoke more than 35 cigarettes a week? Or less than 35 cigarettes in a week? Or you smoke sometimes (occasionally)?

The weight and height of each participant were measured for the purpose of calculation of BMI. A BMI measurement is used to determine if an adult is at a healthy weight for their height. An individual BMI is determined by dividing their weight (Kg) by the square of their height (m) using equation 3.3. Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and heart rate (HR) at resting of the participants were measured with a sphygmomanometer and pulse oximeter. The average of two readings was considered for further analysis. The smoking habits of the participants were measured as "none" if the worker was smoking no more than 35 cigarettes per week, and as "yes", if the worker was taking more than 35 cigarettes per week. Participants were classified as an occasional smoker if they were not a regular smoker and smoking was done occasionally.

For evaluation of the musculoskeletal pain of workers, a pain experience questionnaire consist of nine items was used to assess workers' recognized pain problems. Such a questionnaire that measures the recognized pain was witnessed to be a simplest and accurate approach for pain estimation by many researchers (Tse et al., 2010; Tse et al., 2013; Yi and Chan, 2016). Item No. A of the questionnaire was including optional information such as the name and organization of the respondents. In item No. B of the questionnaire, the discomfort, and pain including muscular, connecting tissue, collagen, and joint discomfort or pain caused by work in the past three months was enquire from participants. The responses of participants were recorded on the questionnaire as "yes" or "no". The workers were also asked to indicate the location of discomfort or pain in figure 3.6 (item C). In items D, E and F of the questionnaire, the workers were asked to rate the severity of pain symptoms on a scale of 1 to 10 (1= very mild pain, 10 = unbearable pain) for the pain they experienced over the past 24 hours and the pain they felt now (items D, E, and F). To know the types of treatment the workers are using for the relief of discomfort and pain, the participants were asked if they had ever used any pain treatment. Responses for the types of treatment were categorized in item G of the questionnaire as follows: ignore the pain, use of pain killers, use of medical cream, carried out massage, use of health product, use of physical therapy, doing exercise, or others treatment. Under item, I of the questionnaire, the response on the relief after treatment was sorted out on a scale of 0 to 10 (0 = no remission, 10 = complete remission). In the last item of the questionnaire, the workers were inquired to rate if their pain has disturbed their daily life by changing their mood, affecting walking and workability, affected their relationships with friends or family, affected their sleeping habits or hobbies. Thus item No. I included six sub-items. The response of the participant was recorded on a scale of 1 to 5. (1= strongly disagree, 5 = strongly agree). The full questionnaire is appended in Appendix II.

The questionnaire used in this part of the research was developed in English. All the respondents were not able to read and write in English, therefore assistance was provided to the respondents to effectively record their response on the questionnaire. There was an option to translate the questionnaire into the local language which the respondents were able to read and write, however, due to the diversity of the respondents, there was more than one language in which the questionnaire was needed to be translated. Even 50% of the respondents were totally illiterate, thus translating the questionnaire to the other languages was not helpful. Thus finally, assistance was provided to all the respondents to effectively record their responses on the questionnaire. This was done through the data collection time when the respondents were required to fill the pain experience questionnaire. The researcher sat with each respondent, translated each question to his local language and given him the available option to record his response on the questionnaire.

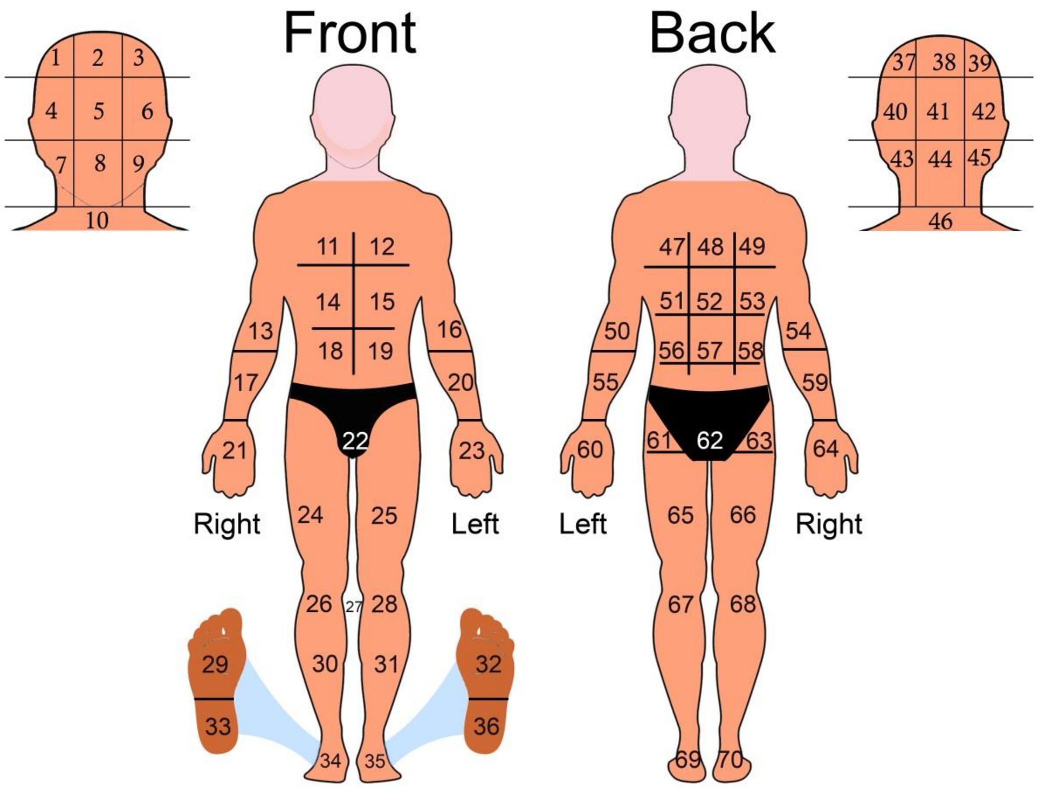


Figure 3. 6: Body areas for Pain Assessment

Statistical analyses were performed using the computer software program SPSS 23.0. For statistical analysis, a descriptive statistics approach which included averages and ratios on different factors were used. To know the significance of sleeping habits on workers' health, a T-test was performed. Briefly T-test is a statistical test that compares two averages (means) and suggests if they are different from each other. The T-test also informs the significance of the differences. In this analysis, two sets of sleeping habit (daily sleeping hours less than seven and equal to seven) was used in relation to musculoskeletal pain. One-way analysis of variance (ANOVA) was run on the average of the workers' health factors such as age, Body Mass Index and smoking habit to establish if there are any important differences between the means of groups. One-way analysis of variance (ANOVA) is a simple method to find out if survey or experiment results are significant or not. It is a useful tool to establish to accept or reject the null hypothesis or accept the alternative hypothesis. Further analyses were conducted on workers who have physical results exceeding the safety verge. The impacts of age, BMI, ethnicity, smoking habit, and working experience on the musculoskeletal pain were determined by performing regressions analysis.

One of the important research objectives of this thesis, as noted in chapter 1, is to investigate the safety climate factors which highly influence the safety climate of construction organization in Oman. Similarly, the literature review presented in chapter 2 (section 2.8) suggests that the safety climate approach to improve the safety performance of organizations has been adopted in many countries. This research also attempts to develop a safety climate assessment tool that could be used in Oman and other GCC countries. The research method adopted to achieve this objective is thus outlined in the next section.

3.3.6 Research Method (Research Objective No. 7: Safety Climate Factors):

The main goal of this research component of the project is to explore the use of safety climate approach and develop a safety climate assessment tool for improving the safety performance of construction organizations in Oman. Different authors recognized that a mature safety climate and a rich safety culture contribute to achieving a safe workplace (Zohar, 2002; Clarke, 2006, 2010; Neal and Griffin, 2006; Wallace et al., 2006; Nielsen and Mikkelsen, 2007; Pousette et al., 2008; Kuenzi and Schminke, 2009; Kines et al., 2011; Umar and Egbu, 2018). The literature review suggests that although there are differences between the two terms i.e. safety climate and safety culture, however these concepts for improved safety performance have attracted more concentration across a broad number of industrial businesses including construction. One of the reasons behind this is that rich safety culture and a mature safety climate are considered among the most important elements in attaining a safer workplace (Bergh et al., 2013). To enhance the level of safety culture and safety climate, it is crucial to, first gauge the existing level of safety culture and safety climate, then agree with what level of safety culture and safety climate is required, obtainable and desired, and then to make strategies to accomplish the safety culture and safety climate, which is desired (AIChE, 2012). A similar concept of safety climate approach was also explained by Umar and Wamuziri (2016) and described relevant safety climate factors or dimensions can be measured among different categories of staff working in a construction organization or in a project undertaken by the construction organization. The results will reflect the safety climate of the organization or the safety climate of the specific project. After the assessment of safety climate factors, construction organizations will be able to identify and prioritize the weak area for improvement. They further suggested that safety climate leading factors can be reviewed on a five-level scoring scale to assess what level of safety culture for that factor is achieved by construction organization. The maturity level for all the factors can be classified as a uniformed, reactive, complaint, proactive and exemplary. Construction organizations can make a short term (1-2 months), mid-term (6-12 months) and long term (1-2 years) plans if the required level for the factors is not adopted by using different ideas.

The first thing which was important to know is the status of the safety climate approach in the construction industry in Oman. For example, is it already in practice or not? If yes, how and if not, then it can be adopted? If this approach (safety climate) can be adopted then what should be the leading factors or dimensions? Which form of assessment of these factors would be more appropriate? Can a tool be developed for construction organizations in Oman which they can use for the assessment of the safety climate? Would they be able to develop different plans to achieve the required level of maturity of a specific safety climate factor? These were the questions that were set for this part of the research.

Three different methods were adopted to carry out this part of the research. Section 3.3.6 (i) explains the first research method adopted in this regard.

3.3.6 (i) Internet Search:

Bryman (2012) while describing the different research methods related to the qualitative research outlined one of the methods as the collection of qualitative analysis of texts and documents. He further explained that websites and webpages can be the potential and reliable sources for both quantitative and qualitative research methods. The main research question for this part of the research was the simple one “what is the most common safety climate factors used in safety climate assessment tools”. The leading safety climate factors identified in this exercise were then discussed with the construction professional working in Oman for further appraisal. To collect the relevant data, an internet search was employed. Since it was revealed from the literature review, that in the last 40 years), the topics of safety climate and safety climate assessment tools were particularly in the focus of construction management researchers. Thus the search period was kept from 1980 to 2018. Clearly, a huge work in the area of safety climate was carried out since 1980, which was defined as a management system period by Hale and Hovden (1998). This was the period of safety which results in the inclusion of safety culture to the safety management system. The approach of safety culture was accurately presented and delineated after the Chernobyl accident which took placed in 1986 (INSAG, 1992). Thus for search criteria, the period of 1980-2018, spanning over a period of 38 years was selected. Two terms “safety climate assessment tools” and “safety climate factors” were used for the search purpose. For screening purpose, only the safety climates factors and tools which were used in construction, utilities and oil, and gas sectors were selected. Further screening was done using the number of Google citations in case the tool or safety climate factors were developed or identified in a research paper. This screening criterion was however not applied to the tools or safety climate factors that were developed or identified by international health and safety organizations or associations. To ensure that a systematic review process is adopted in this study, the research method for the review was guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The PRISMA guidelines required to follow a four steps process to include the final of studies in the systematic review and meta-analysis. These steps include the Identification, Screening, Eligibility, and Inclusion of the existing studies. The full flow diagram with the results of the PRISMA used in this part of the research is given in section 5.2 of chapter 5. The research method used in this part of the research is further explained in figure 3.7.

The next sub-section explains the second research method adopted to achieve the research objective No.7.

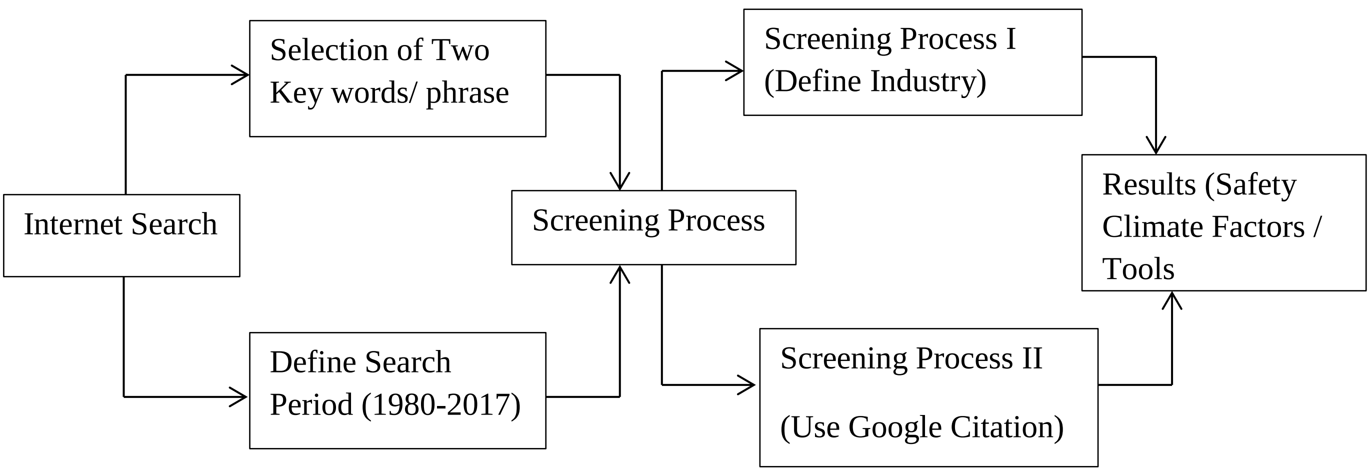


Figure 3. 7: Description of Research Methodology (Internet Search)

3.3.6 (ii) Semi-Structured Interview:

In this part of the research, data were collected from construction industry professionals in Oman on different aspects of safety climate. The purpose of this exercise was to know that either the safety climate concept is adopted in Oman or not? If it has been already adopted, then how it is used? What are the safety climate factors they are using in the assessment of the safety climate of their organizations or projects? How they analyzed the results of their safety climate and how it is used for further safety improvement? If the safety climate approach is not yet adopted, so can it be adopted? If so, what will be relevant safety climate factors which could be more applicable to the Omani construction industry? The leading safety climate factors identified from the literature review in section 3.3.6 (i) were discussed with the respondents and their views on these factors were sought. Similarly, the respondents were also asked about the current methods which construction organizations in Oman are using to improve their safety performance? A semi-structured interview was deemed to be the best fit option to answer these questions. A sample of 20 respondents was selected to answer a set of questions presented in table 3.5.

Table 3. 5: Description of the Interview Questions

Question No.	Description of the Questions
1	*In recent years the awareness of the importance of the safety performance of organizational, managerial and social factors, has increased. Safety climate is a subset of organizational climate, offers a route for safety management, complementing the often predominant engineering approach. What is your opinion on the effectiveness of this new approach to enhancing safety performance in construction organizations?*
2	*Most organizations use records of their health and safety performance as an indication of the effectiveness of their health and safety management and systems. Do you think that an understanding of the safety climate dimensions or factors can be useful in improving the safety performance of construction organizations?*
3	*There is a generally held view by researchers that a mature safety climate can help in building a rich safety culture and there are different dimensions or factors identified which influence safety climate. What is your view on different dimensions or factors that would need to be considered to achieve a mature safety climate and rich safety culture in a construction organization in Oman?*
4	*Researchers and practitioners have identified safety culture and safety climate as key to reducing injuries, illnesses, and fatalities on construction worksites. Many construction contractors are trying to improve these indicators as a way to move closer to the goal of achieving zero injury worksites. Do you think construction organizations in Oman need to adopt the concept of improving safety culture and safety climate to improve their safety performance?*
4	*Safety climate of a construction project or construction organization can be assessed by means of quantitative, psychometric questionnaire surveys, so-called 'safety climate scales', measuring the shared perceptions/opinions of a group of workers on certain safety-related dimensions or factors. The outcome of such safety climate scales is regarded as a predictor or indicator of safety performance. What is your opinion on such a tool? Does your organization use such a tool to assess the safety climate?*
6	*The leading safety climate dimensions or factors can be measured among different categories of staff working in construction organizations or in a project undertaken by the construction organization on a scoring scale of 1-5 (strongly agreed – strongly disagreed). The results will reflect the safety climate of the organization or safety climate of the specific project. After the assessment of safety climate leading dimensions or factors, construction organizations will be able to identify and prioritize the weak area for improvement. What could be the possible format if we want to develop a safety climate assessment tool for construction organizations in Oman?*
7	*Do you think that the assessment of the safety climate will help the decision-making unit (DMU) of construction organizations to develop different plans to achieve the required level of maturity of safety climate?*
8	*Different sizes of construction organizations (small, medium and large) have a different level of resources and competencies. In your view how different sizes of construction organizations will benefit from adopting the concept of improving safety performance through safety climate?*

For the selection of respondents, a specific criterion was used. The interviewees were picked on a deliberative sampling ground. Such sampling is critical in nature and the principles or intention was to interview such respondents who were more appropriate to the research questions. This was accomplished by interviewing a total of 20 top managers from leading construction contractors in Oman. Managers working at the top level with safety responsibilities in construction organizations were considered the most appropriate persons to supply characterizations of the actual world with regard to the safety climate factors. The criteria adopted to select the interviewees were that each interviewee should have at least five years' experience in Oman; the interviewees' company must be an international company and registered as "excellent grade" or "grade one" company with the Tender Board of Oman. Tender board of Oman takes care of all government tenders valued at 3 Million (Omani Rials = 7.79 Million US $) or more (TBO, 2018). The sample size for this study as 20 numbers were considered to be appropriate as described in different studies. From the literature review, it is revealed that 20 numbers of the interview are very commonly used in Ph.D. studies. There have been some studies in the same area, wherein the number of respondents for such an interview was only six (Wamuziri, 2013; Umar and Egbu, 2018; Umar, 2018). A brief description of the interviewees is presented in table 3.6.

Table 3. 6: Description of the interviewees

Interviewee No.	Description of the Interviewees
1, 2, 3, 4	Senior engineers in a construction organization mainly working in the transportation sector in Oman having more than 20 years of project management experience in the highway sector. The company in Oman was initially established in 1973.
5, 6, 7, 8	Senior project engineers in a construction organization working in the housing sector in Oman, with more than 15 years of experience of project management in the building sector. The organization was initially established in 1972 and currently registered as an excellent grade company in Oman.
9, 10, 11	Senior construction managers with more than 10 years of experience in one of the major construction companies with offices in all Gulf Cooperation Council (GCC) countries. The company is 100% privately owned with more than 1,000 employees in Oman. The interviewees are currently working on a highway construction project which has an estimated cost of US $ 305.90 million.
12, 13, 14	Senior construction managers with over 12 years of experience in one of the main construction companies. The Organization was established in the year 1992 and currently executing some of the main building projects pertaining to the government and private sector in Oman. The construction managers interviewed from this organization are working on a construction project of an estimated cost of US $ 60 million.
15, 16, 17	Senior contract managers with over 10 years of experience in one of the world-leading consulting organizations, having offices in the USA, Europe, and the Middle East. The organization was founded in 1944, and 100% owned by the employee stock ownership trust with total revenue of $3.2 billion in 2015.
18, 19, 20	Senior design consultant with more than 8 years of experience in one of the leading international consultants operating the Middle East, Africa, Asia, and Europe with more than 10,000 staff. The interviewees are currently involved as design and supervision consultant in some of the mega road projects in Oman.

Interview questions were asked in the same way by keeping the sequence of questions similar in all interviews. Manual notes were made in each interview for recording their responses. Data was collected in a manner to which the content analysis technique can be applied easily. This includes coding the whole text/ script, identifying the themes with broader patterns of meaning and defining and naming each of the themes.

The next section (3.3.6 (iii) shed the light of the third research method that aims to achieve the research objective No.7 associated with safety climate.

3.3.6 (iii) Questionnaire Survey:

This part of the research is linked to the safety climate factors. The factors included in this questionnaire were based on the data collected in the first and second parts of this research. The data collected in the first part (section 3.3.6 (i)) was from the existing literature in which the most common safety climate factors were identified. Similarly, the data collected in the second part (section 3.3.6 (ii)) of the research was linked existing literature review (3.3.6 (i)), however, it was only from a specific group of construction professionals. The number of respondents in the semi-structured interview was also twenty, which doesn't help to generalize the results. Similarly, the construction team of an organization or construction project consists of Managers, Engineers, Site Supervisors, Foremen, and Workers, therefore their view of different safety climate factors derived from the semi-structured interview was considered to be important. This was done through data collection using a questionnaire and a mix of different respondents. Briefly, the safety climate factors identified through the internet search and semi-structured interview, are Commitment from Management to Enhance Safety, Alignment and Integration of Safety as Value, Enforcing Accountability At All Level, Enhancing Workplace Safety Leadership, Empowerment, and Involvement of Workers, Enhancing Communication, Ensuring Training for all staff, and Encouragement of Owner and Client Participation.

Data was collected from a variety of respondents that includes managers, engineers, site supervisors, foremen, and workers. A construction organization registered as an excellent grade with the Tender Board of Oman was considered to be the best place to have the appropriate number of the required respondents in each group. The normality of the data was checked through the ratio between skewness and its standard error, and the ratio between kurtosis and its standard error. The data was considered normal if the ratio was between – 1.96 to + 1.96. Briefly, Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Similarly, Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. Data sets with high kurtosis tend to have heavy tails or outliers. Data sets with low kurtosis tend to have light tails or a lack of outliers.

A simple questionnaire was adopted for recording the response of the respondents using a Likert scale (Appendix III). Part I of the questionnaire is related to the personal / background information of the respondents. This information includes the birth year, gender, position/role, academic qualification, experience, age group and country of birth. In Part II of the questionnaire, the respondents were asked to rate their responses related to management commitment on a scale of 1 to 5. (1= strongly disagree, 5 = strongly agree). In part II there is a total of 10 questions. These questions are related to “management commitment”. Part III is related to the “alignment and integration of safety as value” and there is a set of 11 different questions. In Part IV, there are 10 questions that are related to “accountability at all level”. In part V, which is related to “improvement of site safety leadership”, has a set of 8 questions. There are 7 questions in part VI entitle as “empowering and involving workers”. Part VII of this questionnaire is related to “improvement of communication” and it has 9 questions. There are 7 questions in part VIII (training at all levels). Part IX is related to “encouragement and involvement of owner/client” and it has 10 questions. In part X of the questionnaire, the respondents were requested to rate the relevancy of different safety climate factors. The last section of the questionnaire (part XI) is provided for the comments of the participants. If the participants may have any comments, it will be written in this part of the questionnaire. The questionnaire was developed in the English language and the necessary assistance was provided to the respondents who were not able to read and write in English. One of the options to translate the questionnaire into the local languages of the respondents; however it was not a feasible option due to the diversity of the sample available. Respondents in this part of the research were from different Asian countries which increases the reliability of the sample. For instance, the construction industry workforce as reported by the Oman Society of Contractors consists of 92% of foreign workers. The Omani working in the construction sector, therefore, stands at 8% only (Umar, 2016). Similarly, the National Centre of Statistics and Information (Oman) data for the year 2014 shows that the Indian workers (5,550,470) were on the top in private sectors in Oman followed by Bangladeshi (537321) and Pakistani (210,632) workers as shown in table 3.7 (NCSI, 2015).

Table 3. 7: Distribution of Expatriate by Nationalities and Gender in Private Sectors in Oman (NCSI, 2015)

Nationality	Male	Female	Total
Indians	5,523,963	26,507	**5,550,470**
Bangladeshi	515,628	21,693	**537,321**
Pakistani	209,881	751	**210,632**
Indonesian	608	35,109	**35,717**
Ethiopian	312	32,968	**33,280**
Philipinos	9,013	17,112	**26,125**
Egyptians	12,251	1,896	**14,147**
Nepales	8,888	3,257	**12,145**
Sirilankans	5,309	6,218	**11,527**
Other Nationalities	35,157	15,421	**50,578**
Total	**6,321,010**	**160,932**	**6,481,942**

The questionnaires received with signed in informed consent were used in the analysis and results. The raw data obtained from the questionnaires were processed using SPSS, data analysis software. To calculate means scores for each factor or dimension of safety climate and individual, the raw data from different items were used. As a rule for data analysis, only the answered items of the questionnaire were used. If in a specific dimension or factor, a respondent has answered less than 50% of the items, thus all answers were excluded for that dimension. This was done based on the fact that a mean score based on less than 50% of items is not considered as valid. For the calculation of the mean score of each dimension and group, the mean score of different dimensions or factors and individuals were used. In further analysis, the mean scores for all the dimensions were utilized. An independent sample T-test (two-tailed) was conducted to see if there is any notable variation among two independent groups. A probability value (p-value) less than 0.05 from two-tailed T-test was treated statistically powerful for all tests. Cronbach's alpha coefficient which is also known as the coefficient of reliability was calculated to check the internal consistency of the different safety climate factors. The mean values of each item in different safety climate factors were used to rank items in the same factor. Item ranked as 1, mean that that item in a safety climate factors was considered important by the respondents to enhance the maturity level of that factor. To rank the individual safety climate factors used in the questionnaire, an "importance factor" based on the mean value and the Cronbach's alpha value is calculated. The importance factor of each safety climate factor is obtained by the multiplication of the mean score with the Cronbach's alpha value of that safety climate factor. A similar approach for ranking different factors related to the application of unmanned aerial systems (UASs) for construction safety was also used by Gheisari and Esmaeili, (2019).

The content analysis technique was adopted to examine comments written in the last section of the questionnaire. Graneheim and Lundman (2004) guidelines were used for content analysis. Based on this method the meaning units which have the same central meaning, from the comments section were organized from most common to least common. Content analysis is a research method that is applied to make replicable and valid inferences by defining and coding textual materials. Through a systematic examination of data such as documents, oral communication, and graphics, qualitative data can be translated into quantitative data. Although this approach of research has been used widely in the social sciences, only recently has it become more common among organizational researchers. The content analysis technique is common now in organizational research because it permits researchers to find and evaluate the nuances of organizational behaviors, stakeholder feelings, and social tendency. It connects both the quantitative and qualitative research methods by playing the role of a bridge. At one aspect, the content analysis permits researchers to evaluate socio-cognitive and perceptual constructs which are hard to examine through usual quantitative research methods. Similarly, at the same time, it gives a chance to the researchers to collect large samples which are normally hard to adopt in purely qualitative research.

The next sections briefly explained the statistical tests used in this part of the research considering their purpose and importance.

3.3.6 (a) The t-test (two-tailed):

In statistical analysis, a one-tailed test and a two-tailed test are the different methods of calculating the statistical importance of a variable collected from a data set. A two-tailed test is utilized if deviations of the calculated variable in either direction from a benchmark value are recognized theoretically possible. In contrast, a one-tailed test is applied if only deviations in one direction are recognized possible (Kock, 2015). Other names of these tests are one-sided and two-sided tests. The wording "tail" is used due to the utmost shares of distributions, where examinations allow for the refusal of the null hypothesis, are small and often "tail off" toward zero as in the normal dissemination or "bell curve" as shown in figure 3.8.

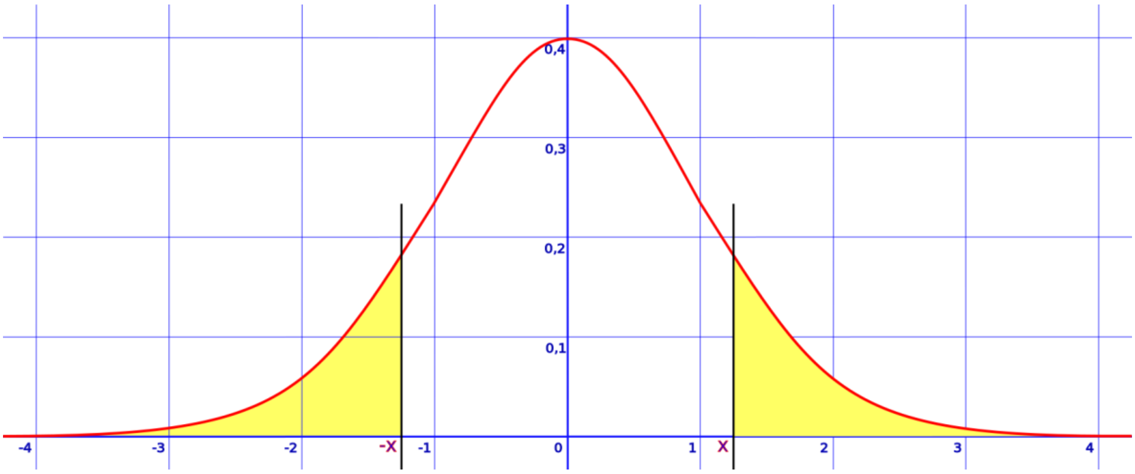


Figure 3. 8: Two-tailed t-test with normal distribution

3.3.6 (b) p-value (probability value):

In statistical analysis, the p-value is a power of the monitored sample results (a statistic) that is used for testing a statistical hypothesis. More accurately, the p-value is described as the probability of achieving a result equal to or "more extreme" than what was actually observed, assuming that the null hypothesis is valid. The term "more extreme" is dependent on the way the hypothesis is tested. A threshold value, known as the significance level of the test is selected before this test is performed. Normally, this significance values are 5.0% or 1.0%. In this research, a probability value (p-value) less than 0.05 from two-tailed T-test was considered statistically significant for all tests. The p-value is further demonstrated in figure 3.9.

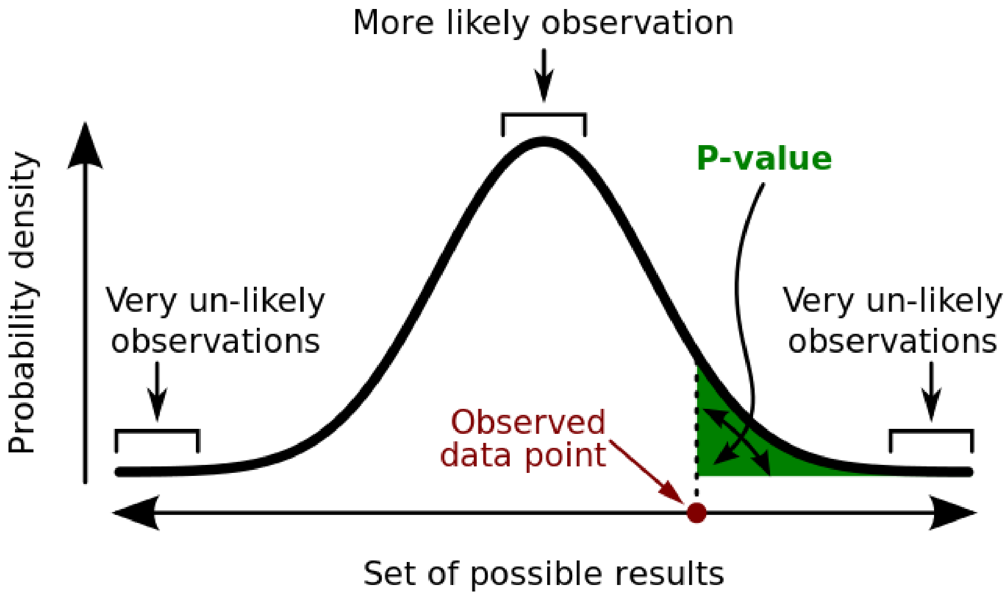


Figure 3. 9: Representation of p-value

3.3.6 (c) Cronbach's alpha coefficients (coefficient of reliability):

Cronbach's alpha is a measure of inner stability, which reflects how closely related a set of items are as a group. It is regarded to be a measure of scale reliability. The "high" value for alpha does not indicate that the measure is unidimensional. If, in addition to estimating the inner stability and it is necessary to show the proof that the scale in question is unidimensional, further analyses can be conducted. For instance, exploratory factor analysis can be performed, which is one of the methods to check dimensionality. Thus, Cronbach's alpha is not regarded as a statistical test, but it is a coefficient of reliability or consistency. Mathematically, Cronbach's alpha can be expressed as a function of the number of test items and the average inter-correlation between the items. The standardized formula for the Cronbach's alpha is as shown in equation 3.4.

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$ …………..Equation 3.4

Where;

N = number of items

$\bar{c}$ = the average inter-item covariance among the items

$\bar{v}$ = the average variance.

3.3.6 (d) Spearman's Correlation Coefficient:

The Spearman's Correlation Coefficient, represented by ρ or by r_s, is a nonparametric measure of the strength and direction of the association that exists between two ranked variables. It determines the degree to which a relationship is monotonic, i.e., whether there is a monotonic component of the association between two continuous or ordered variables. Generally, it is noted by r_s and is by design constrained as follows;

$-1 \leq r_s \geq 1$

Its interpretation is similar to that of Pearsons, e.g. the closer is to the stronger the monotonic relationship. Correlation is an effect size and so it can verbally describe the strength of the correlation using the following guide for the absolute value of r_s.

- 0.00 - 0.19 "very weak"
- 0.20 - 0.39 "weak"
- 0.40 - 0.59 "moderate"
- 0.60 - 0.79 "strong"
- 0.80 - 1.0 "very strong"

The following equation is normally used to determine the Spearman Correlation.

$rs = 1 - \frac{6\sum idi^2}{n(n^2-1)}$ ………….. Equation 3.5

Where n is the number of data points of the two variables and d_i is the difference in the ranks of the i^{th} element of each random variable considered.

The next section describes the sample size selection for the safety climate study.

3.3.6.1 Sample Size (Safety Climate Study):

Generally, the sample size is calculated from the population size. In this part of the research the population size is reflected by two variables i.e. i) the number of construction workers in Oman and ii) the number of construction companies under consideration. For example, in the first case, the total workforce in Oman is 700,000 and in the second case, the number of construction companies under consideration i.e. excellent and first grade is 683 (table 3.2). Similarly, to calculate the sample size the margin of error is also chosen. The margin of error represents the percentage that describes how closely the answer of the sample gave is to the "true value" is in the population. The smaller the margin of error is, the closer to having the exact answer at a given confidence level. The confidence level is a measure of how certain the sample accurately reflects the population, within its margin of error. Common standards used by researchers are 90%, 95%, and 99%. Mathematically the sample size can be calculated by using equation 3.1 and equation 3.2. These equations give a sample size of 307 and 319 if the confidence level and margin of error are set as 95% and 5% respectively. Clearly, the sample size is highly influenced by the population size. In other words, the sample size increases if the population size increase and this is basically helpful to generalize the results. In some cases, the sample size calculated by these equations could not be helpful or even not adoptable. For instance, the population is the 'population of China'; then the sample size calculated through these equations will be very large and thus could not be achieved. Considering the scope of this Ph.D. research project and the aim of this part of the research, it was aimed to have at least 100 responses from the selected. Mathematically it was justified through the equation developed Green (1991) as mentioned in equation 3.6.

$N \geq 50 + 8p$ ……………………Equation 3.6

Where;

N = Sample Size

p = number of predictors.

Using the above equation and considering the safety climate questionnaire which aims to target at least 100 responses, the p-value can be 5 or 6. Thus the sample size can be as under:

For p = 5

$\geq 50 + 8 \times 5 = 90 < 100$; thus OK

For p = 6

$\geq 50 + 8 \times 6 = 98 < 100$; thus OK

Thus in both cases, the sample size is valid. The actual responses collected in this part of the research were, however, 102. Similarly, sample size can also be validated through the variable "age of the respondents" using equation 3.7.

$N = \left(\frac{Z\sigma}{d}\right)^2$ …………….Equation 3.7

Where,

N = Minimum sample size

Z = Constant value which depends on confidence level, for instance, if the confidence level is 95% then the Z value will be 1.96 (table 3.3)

σ = Standard deviation

d = error

The sample size used in this part of the research was also validated through this equation and was found to be adequate.

The process of developing a new safety climate assessment tool is described in the next section.

3.3.6.2 Safety Climate Assessment Tool:

Based on the results and analysis of the data collected in sections 3.3.6, a safety climate tool assessment tool was developed. All the safety climate factors which achieved a mean score of more than 3 were considered significant and were therefore used in the new tool. Similarly, the Cronbach's alpha value is also used to rank the safety climate factors for inclusion in the safety climate assessment tool. The importance factor described in section 3.3.36 (iii) is used for this purpose. While considering the mean score of the safety climate factors for the inclusion in the safety climate assessment tool, the importance factor is also considered. Thus any safety climate factor achieved an importance factor score more than 1 were included in the safety climate assessment tool. If the importance factor score of a safety climate factor was less than 1, it was excluded from the safety climate assessment tool. Factors which achieved high score were ranked first and were numbered accordingly. Sub-items in each tool were also ranked based on their mean score. The final safety climate assessment tool was then circulated through email to a total of 50 mangers of the selected construction organizations using the email interview practice as described by Burns (2010). The criterion for the selection of the respondents used for this exercise was the same as the criteria adopted for the respondents in section 3.3.6. The purpose of this exercise was to obtain feedback on the newly developed safety climate assessment tool from the industry professional.

A summary of this chapter that highlights the important research approaches is provided in the next section.

3.4 Summary:

In this chapter, the research methodology and research methods used to accomplish different research objectives of this project were discussed in detail. Due to the complex nature of the research project, both the quantitative and qualitative research methods were considered to be deemed fit and thus both were employed. The data collection techniques and processes for each method were explained with relevant justifications. Table 3.8 summarizes the sample used for data collection along with methods adopted in the different parts of the research involving a total of 191 construction workers and professionals. There were other data used in this research, which has been collected using different techniques. For instance, for the cause of accidents, different types of accidents were received from partner construction organizations. Similarly, for occupational safety and health regulations, data in the form of documents was obtained from open sources. For example, the International Labour Organization conventions applicable to safety and health-related issue were obtained from their website. To check either Oman has rectified specific conventions or not, the information on the same website is used and was considered as accurate. To estimate the cost of accidents in construction, data from the literature review was examined. The cost of accidents as a ratio of the project value was established from the literature review. The same ratio was applied to the value of construction projects in Oman. For the compensation cost in case of injuries, the data available on the Public Authority of Social Insurance website was used. The compensation ratio was determined by dividing the total number of registered insurees by total disbursed amount in a specific period. Thus the cost of accidents was calculated using two criteria i.e. a) cost of the accident based on project values, and b) cost of the accident based on compensation cost.

Table 3. 8: Description of Research Methods and Samples

S.No.	Description of the Research Component	Research Methods	Sample Size	Remarks
1	Heat Stress	- Qualitative (face to face interview) - Physical Examination (Body Mass Index, Blood Pressure)	20 20	Same workers in both cases
3	Construction Workers Health Profile and Pain Experience	- Qualitative (face to face interview) - Physical Examination (Body Mass Index, Blood Pressure) - Quantitative (Pain experience Questionnaire)	30 30 30	Same workers in all three cases
3	Safety Climate (Development)	- Qualitative (Semi-Structured Interview) - Quantitative (Questionnaire)	20 102	Different workers in both cases
4	Safety Climate Assessment Tool (Validation)	Qualitative (Feedback through emails)	19	--

Internet search was also used as part of data collection in the safety climate research part. To do this internet search two terms/phrases related to safety climate were selected. One of the terms/phrases used for this purpose was “safety climate assessment tools” while the second selected term/ phrase was “safety climate factors”. As discussed in sections 1.2 and 2.8, the safety climate approach gets more attention since 1980, the search period was, therefore, set from 1980 to 2017 (37 years). A specific period spanning over a time of 37 years derived from the literature review was selected to do this internet search. For the screening purpose to narrow down the results, different thresholds were applied. Google citation was one of them if the safety climate tool or safety climate factor/ dimension were developed in a research paper. Similarly, industrial orientation was also used for screening purposes. Overall, a safety climate tool or safety climate factor/ dimension which was developed for and sued in construction, utilities, and oil and gas was only selected. Data related to annual minimum and maximum temperature was obtained from the Directorate General of Meteorology in Oman. Newspaper reports were also considered as part of an independent source of temperature data in Oman.

The description of data collection tools that were used in both qualitative and quantitative research is also given in this chapter. There have been three tools used for data collection in the face to face interviews. The face to face interview was part of the heat stress, worker's health profile, and safety climate research. The respondents for semi-structured interview questions in safety climate research were selected using specific criteria. These criteria include that the respondent should be working at a senior position and have at least five years' experience in Oman. The organization of the respondents must be registered as an international company in excellent grade with the Tender Board in Oman. Two questionnaires were used in the data collection stage. One is liked to pain experience of construction workers and the other one is used for safety climate factors. The pain experience questionnaire has a total of seven parts including i. Personal Information/ Organizational Information/ Optional Information, ii. Pain Experience information in the past three months, iii. Location of the pain, iv. The severity of pain, v. Treatment of pain, vi. Result of treatment of pain, and viii. Impact of pain on daily life.

The safety climate questionnaire has a total of ten parts. The entire question except in the first part and the last part are Likert scale questions using a scale from 1-5 (1 = strongly disagree, 5 = strongly agree). Part one of the questionnaire is related to the personal and background information of the respondents which has a total of seven items. The last part of the questionnaire was related to comments. This section is provided for the respondents if they have any additional comments, they can write in this section. The middle parts of the questionnaire were related to safety climate factors that include a) management commitment (10 items), b) alignment and integration of safety as value (11 items), c) accountability at all level (10 items), d) improvement of site safety leadership (8 items), f) empowering and involving workers (7 items), g) improvement of communication (9 items), h) training at all level (7 items), i) encouragement and involvement of owner/client (10 items), and j) The relevance of different safety climate factors (8 items).

Physical examination including Body Mass Index and Blood Pressure measurement was part of the heat stress research. The weight and height of 20 volunteer construction workers were measured to calculate the Body Mass Index. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were measured under the supervision of a medical practitioner using a sphygmomanometer. The average to two readings was considered for further analysis. The volunteers selected for this measurement were involved in different types of accidents in their projects. These volunteers were further interviewed to ascertain the impact of heat stress on their safety performance. Considering the diversity in the construction industry in Oman, the sample was selected in a way to avoid language barriers. Thus, volunteers who were able to speak and understand the local languages such as Urdu, Pushto, Hindi, and Punjabi were only selected. Apart from the Body Mass Index and blood pressure, heartbeat measurement was also part of the worker health profile research. In this part of the research, data was collected from a total of 30 volunteer construction workers. The language barriers were also considered in this part before choosing volunteers for a face-to-face interview. Different statistical tests for data analysis were conducted using SPSS software. The most common tests/ parameters used in this research are mean, AVONA, T-test, p-vale and Cronbach's alpha coefficient. To ensure that the data collection process is aligned with appropriate research ethics, the following professional associations' guidelines were used.

1. British Educational Research Association Revised Ethical Guidelines for Educational Research (BERA, 2011), Available online at: https://www.bera.ac.uk/wpcontent/uploads/2014/02/BERA-Ethical-Guidelines-2011.pdf

2. The British Psychology Society, Code of Human Research Ethics (BPS, 2014). Available online at: https://www.bps.org.uk/sites/bps.org.uk/files/Policy%20-%20Files/BPS%20Code%20of%20Human%20Research%20Ethics.pdf

3. American Psychological Association Research Ethics (APA, 2016). Available online at: http://www.apa.org/ethics/code/index.aspx

Data collection was started after the ethical approval from the ethical committee of London South Bank University, UK. The ethical approval process was started in early 2018 after the successful completion of the progress reports and panel confirmation. The final approval from the ethical committee was received in November 2018 (Appendix IV).

The next chapter of the thesis is the “Results, Analysis and Discussion” chapter which provide an in-depth insight of all the analysis carried out on the collected data and present the results of each element of the research excluding the safety climate. The results, analysis, and discussion on safety climate are provided in chapter 5.

Chapter 4: Results, Analyses and Discussion

4.1 Introduction:

This chapter summarized the results, analyses, and discussion obtained from different parts of this research. The chapter is divided into two main parts. In the first part, the results and analysis of the study are presented. The second part of the chapter provides a discussion on the results and analysis. The first section describes the result of the causes of accidents. This part is further subdivided into five sections. The next part is of the chapter is related to the cost of accidents which has a total of three sub-sections. Similarly, the third part of the chapter outline the results and analysis of heat stress study which is divided into three parts namely “Trends of Accidents”, “Semi-Structured Interview” and “BMI and blood pressure”. The “Occupational Safety and Health Regulations” are covered in the fourth part of the chapter in which regulations related to fall protection, hazard communication, scaffolding and status of International Labour Organization convention are discussed. Construction Worker health factors are covered in a total of five subsections of the chapter. The discussion on the results and analysis are provided in section 4.7. This section has a total of seven sections. Finally, the last section provides a summary of the chapter.

The next sections of the chapter describe the results and analyses of each part of the research undertaken in this project.

4.2 Causes of Accidents in Construction in Oman:

The main research question in this part of the research project is to identify the main causes of accidents in construction in Oman. The methodology adopted in this research includes the collection of actual accident data from a construction organization that just completed a major highway project. Five main construction organizations that were involved in delivering the project were asked for cooperation to investigate the root causes of the accidents on the project. These organizations were informed about the purpose of the research and the information required for the purpose of the research. Only one construction organization agreed to cooperate on the condition that the name of the organization would not be revealed. This construction organization was carrying out a 75 km road construction project that has an estimated cost of US $ 305.90 million. The project was started in September 2011 and 82 % of the work was completed in April 2016. The data of 623 accident data was provided by the Safety and Health team of the project. These accidents were of different types of nature. Based on the accident data, the different types of accidents were initially classified based on the criteria mentioned in table 3.1.

To find the root causes of these incidents, a model was developed to identify the causes of accidents and to relate them to the main causes of Material / Equipment, Workers, Environment, and Management as shown in table 4.1. These main causes of accidents were identified from the literature review on different models of root causes of accidents in construction discussed in sections 2.3 and 3.3.1. All the accidents were trace against the criteria shown in table 4.1 and were classified accordingly. The provided data covers the accidents in the project spanning over a period of 4.5 years, from September 2011 to April 2016. Thus these accidents were also classified 'yearly' as they occurred (table 4.2). Overall, the average number of workers on the project during this period (September 2011 to April 2016) was 2000. The result shows that there was no accident in 2011. In the year 2012, there was seven 'property/equipment damage', one AWI, one FAI, and two MTI accidents. There were 155 'property/equipment damage'; three were FAI, three were LTI and four were MTI in 2014. Similarly, in the year 2014, there were 164 'property/equipment damage', two were AWI, five were LTI and five were MTI accidents. The year 2015 hits the highest number of accidents of 193, in which 179 were 'property/equipment damage', two were 'AWI', seven were 'FAI', one was 'LTI' and four were 'MTI'. There were only 78 accidents in 2016, in which 75 were 'property/equipment damage' and three were FAI accidents. The data shows a small number of accidents in 2016, but this was due to the fact that the data covers only four-month of 2016. The remaining data for eight months was not provided.

Table 4. 1: Model for Tracing Roots Causes of Accidents

Equipment / Materials	Worker	Environment	Management
There was excessive noise from equipment or machines involved in the incident.	The worker involved in the incident was under fatigue/stress.	There was an ambient condition (wind, dust, rain, etc.) at the pace of the incident.	The incident was caused by the hazardous method specified.
The machines, equipment or tools which were involved in the incident were difficult to operate.	The worker involved in the incident was having a physical disability which was affecting performance.	There was excessive noise at the place of the incident.	The incident was caused by a lack of supervision/supervisor competence.
The machines, tools or equipment involved in the incident were malfunctioning or defective.	The incident was caused by the worker's culpable act.	The incident was caused by poor lighting.	The incident was caused by the non-provision of correct safety equipment or clothing.
The materials/equipment involved in the incident were difficult to handle and maintain.	The incident was caused by worker skylarking or misconduct.	The incident was caused by terrain conditions.	The incident was caused by inadequate training provided.
There was inadequate guarding or protection with the machines, tools or equipment involved in the incident.	The worker involved in the incident was having personal problems.	The incident was caused by temperatures.	The incident was caused by poor housekeeping standards.
The machine tools or equipment involved in the incident is manual handling.	The worker involved in the incident was inexperienced in the task being performed.	The incident was caused by poor housekeeping.	The incident was caused by poorly maintained equipment.
	The incident caused by the failure of worker to use safety clothing.	The incident was caused by building surface conditions (stairs, floors, etc.)	The incident was caused by the non-availability of suitable plant/equipment.
	The worker involved in the incident used a hazardous work method.	The incident was caused by the storage / staking of material.	The incident was caused by inadequate or non-documented procedures.
	The worker involved in the incident was under the influence of alcohol or drugs.	The incident was caused by exposure or contact chemicals or other harmful material.	The incident was caused by insufficient/inadequate instruction or information.
	The incident caused by the act or omission of another person or worker.	The incident was caused by exposure to infectious sickness/disease.	The incident was caused by production pressure from a supervisor or manager.
		The incident was caused by poor visibility.	
		The incident was caused by a congested work area.	

Table 4. 2: Classification of Accidents

Year	**Property / Equipment Damage**	**Alternate Work Injury (AWI)**	**First Aid Injury (FAI)**	**Loss Time Injury (LTI)**	**Medical Treatment Injury (MTI)**	**Total**
2011	0	0	0	0	0	**0**
2012	7	1	1	0	2	**11**
2013	155	0	3	3	4	**165**
2014	164	2	0	5	5	**176**
2015	179	2	7	1	4	**193**
2016	75	0	3	0	0	**78**
Total:	**580**	**5**	**14**	**9**	**15**	**623**

Considering the importance of safety and health inspections to ensure proper health and safety at the workplace, the project health and safety team was requested to provide the record of all internal and external inspections related to safety and health carried out during the same period for which the accidents data was provided. The inspection record shows that there were a total of 2392 safety and health-related inspections carried out during the same period (September 2011 to April 2016). The number of internal inspections conducted by the project health and safety team was 2376. The project health and safety team was constituted by one health and safety advisor and five health and safety officers. The contractor head office 'health and safety' team conducted a total of 12 inspections. There were four inspections conducted by different government agencies out of which two were carried out by the Civil Defence authority in 2013, One by Ministry of Manpower in 2014 and the last one was by the Ministry of Environment and Climate Affairs in 2015. Table 4.3 shows the record of 'health and safety' internal and external inspections conducted from 2011 to 2016 on this project.

Table 4. 3: Summary of Internal and External Inspections on the Project (September 2011 to April 2016)

Year	Internal Inspections by Project HSE Team	External Inspections by Contractor Head office HSE Team	External Inspections by Government Authorities	Total
2011	0	0	0	**0**
2012	461	4	0	**465**
2013	791	2	2	**795**
2014	535	3	1	**539**
2015	406	3	1	**410**
2016	183	0	0	**183**
Total:	**2376**	**12**	**4**	**2392**

The Health, Safety, and Environment policy of the construction organization from which the accident data were obtained, define the procedure for incident reporting, which requires the workplace manager and health and safety in-charge to determine, whether a specific incident requires further investigation or not. The process of reporting an incident by the workplace manager and the health and safety in-charge includes the collection of the necessary information to determine what happened, where and who was involved. To understand the causes of different accidents that occurred on the project, the project team was requested to provide the incident investigation reports so that detailed analyses could be conducted. A total of 44 different incident reports were provided by the health and safety team of the project. These reports were initially assessed against the model developed for tracing the root causes of accidents. It was found that only 22 reports had sufficient information to be used for tracing the root causes. Thus the valid accident data used are 50% of the total accident reports received from the health and safety team of the project. Out of 22 reports, nine incident reports were classified as property/equipment damage, one as AWI (Alternate Work Injury), two FAI (First Aid Injury), five MTI (Medical Treatment Injury) and five as LTI (Loss Time Injury). A different set of questions was developed and applied to each incident. The model was validated by top management, including the health and safety advisor, construction manager and project director of the construction organization. All the valid incidents reports were reviewed against these questions and a conclusion was made on the main or root causes of each incident.

After reviewing the incident reports against the set of questions shown in table 4.1, eight incidents were matched to one root cause. The remaining incidents (14 incidents) were having more than one main root cause (table 4.4). In 2012, complete reports of seven incidents were provided by the project health and safety team. Two incidents matched to one root cause of “worker” and another to “management”. The remaining four incidents in 2012 had more than one root cause. From eight valid accident reports of 2013, one incident was matched to “worker” as a root cause while the remaining seven incidents had more than one root cause. In the year 2014, there were two valid accident reports available. One incident had the root cause of “material/equipment” and one incident to the root cause of “worker”. The total valid accident reports for the year 2015 were five out of which two incidents matched one root cause of “worker”; the remaining three incidents were having more than one cause as shown in table 4.4. Considering individual causes, for 5 incidents, “equipment/material” was one of the root causes. For 17 incidents, “worker” was one of the root causes of accidents. “Environment” was one of the root causes for 5 incidents; “management” was one of the root causes for 13 incidents, and equipment/material was one of the root causes for 6 accidents.

Table 4. 4: Summary of Accidents Classification and Root Causes of Investigated Accidents

Year	Accident Classification	Root Cause	Total
2012	Property/ Equipment Damage	Environment + Management	**7**
	AWI	Worker	
	Property/ Equipment Damage	Worker	
	FAI	Environment + Management	
	Property/ Equipment Damage	Worker + Management	
	Property/ Equipment Damage	Management	
	MTI	Equipment + Worker + Management	
2013	Property/ Equipment Damage	Worker + Environment	**8**
	Property/ Equipment Damage	Worker + Management	
	MTI	Equipment + Worker + Management	
	Property/ Equipment Damage	Worker + Environment + Management	
	LTI	Worker	
	MTI	Worker + Management	
	MTI	Worker + Management	
	Property/ Equipment Damage	Equipment / Material + Management	
2014	LTI	Equipment / Material	**2**
	LTI	Worker	
2015	Property/ Equipment Damage	Equipment / Material + Worker	**5**
	FAI	Worker	
	LTI	Worker	
	MTI	Equipment / Material + Worker + Environment + Management	
	LTI	Worker + Management	
		Total	**22**

A detailed discussion of the results and analyses of the causes of accidents is made in section 4.7.1. The next section presents the results and analyses of the costs of accidents derived from the research method explained in section 3.3.2 of chapter 3.

4.3 Cost of Accidents in GCC:

The Cost of Accidents in GCC construction estimated in this research is based on a number of assumptions and co-relations as there is a lack of availability of the raw data required for this purpose. For example, there is no organization in any of the GCC countries similar to the organizations available in the United States (for instance OSHA), UK (for Instance HSE) or Australia (for instance Safe Work Australia). The cost of accidents is estimated from the available data considering the three countries from the GCC including Qatar, Oman, and Saudi Arabia.

4.3.1 Cost of Accidents in Qatar:

The cost of accidents in Qatar is calculated based on the value of construction projects in 2018. The data published by a unique conference series related to the projects in Qatar "Project Qatar" shows that the value of Qatar's major construction projects stood at US$ 117.44 Billion (PQ, 2018). The average ratio of the costs of accidents established in section 2.4 of the literature review chapter which is equal to 7.5% of the total project value was used to determine the costs of accidents in the Qatar construction industry. Based on this rule, the total costs of accidents in the Qatar construction industry will be US$ 8,808 Million. The details of each category of the projects are shown in figure 4.1.

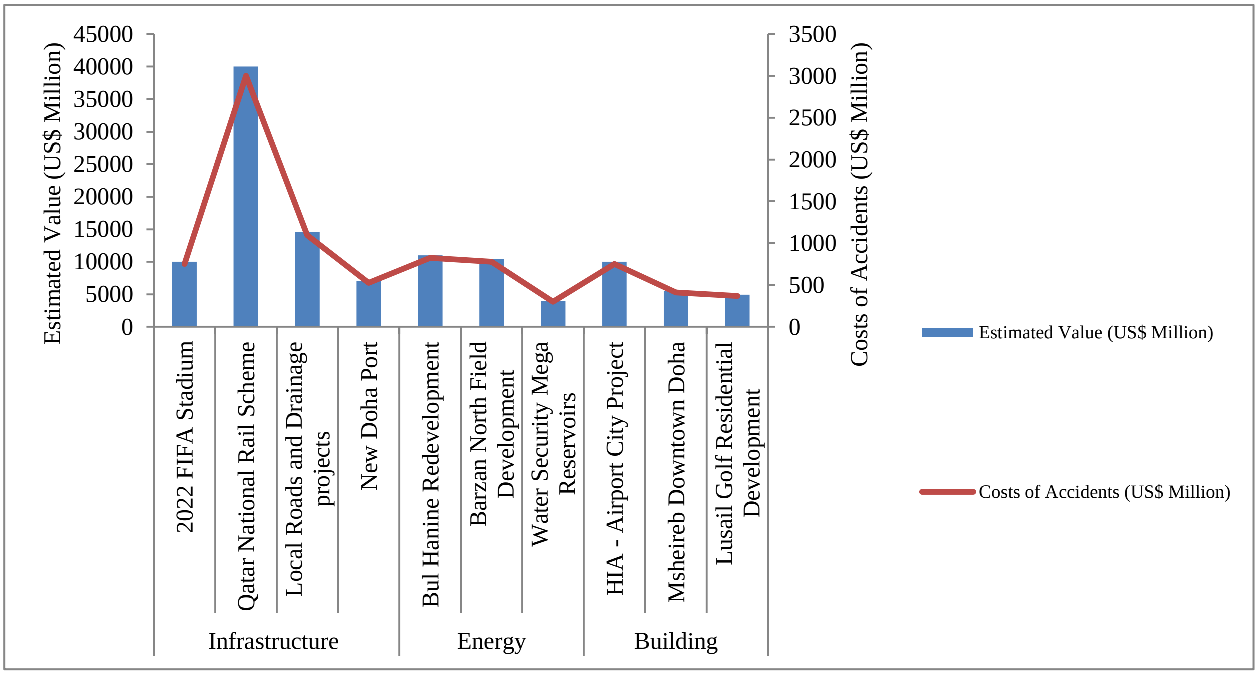


Figure 4. 1: Costs of Accidents in Construction in Qatar

Similarly, one of the main project which has attracted the attention of the local and international organizations not only because the next football world cup will be held here but also because of the worker's deaths in this project. Some of the reports show the number of construction workers that died in this project has already reached 1,200. Several estimates predicting the number of deaths will reach 4,000 by the end of 2022 when the project will be completed (SM, 2018; ITUC, 2014; Ganji, 2016). If the costs of these accidents are estimated on the assumption that fatality costs in UK and Qatar are the same (~US$ 1,870,437), 1,200 fatalities will result in a total cost of US$ 2,245 Million. Similarly, if the death toll will reach 4,000 deaths by the end of this project, this will put a burden of US$ 7,482 Million. Of course, this should be considered that this estimate presents the costs of fatalities arising from accidents in one construction project. This reflects that the actual burden on the Qatari economy from the costs of accidents in construction will be much more than the one quoted here.

Similarly, the statistics published by the General Retirement and Social Insurance Authority (GRSIA) of Qatar for the year 2017, show that there were 75 deaths and one disability caused by work-related accidents in 2017. This is important to note that GRSIA only registers Qatri or GCC citizens into its insurance system. The total expenditures (benefits) caused by these deaths (~USD 4.31 Million) and disability (~1.37 Million) were US$ 5.68 Million (GRSIA, 2017). The average indirect costs of one accident result in death or disability is, therefore, equal to US$ 74,737. To determine the direct costs of these accidents, the equation developed by Haupt and Pillay (2016) was used. The assumption here is that the direct costs of an accident are half of the indirect costs. The total costs of an accident are calculated using equation No.1, which is equal to US$ 205,526. The costs of an accident in Qatar (~US$ 205,526) are almost nine times more than the average costs of an accident in the USA, UK, AUS, and SA (US$ 25,450) – refer to figure 2.12.

$TCA = DC + 2.25\ IDC$ ……………..Equation No.1

Where;

TCA = Total Costs of an Accident

DC = Direct Costs of an Accident (~US$ 37,368)

IDC = Indirect Costs of an accident (~US$ 74,737)

The next section presents the results and analysis of the cost of accidents in the Omani construction industry.

4.3.2 Cost of Accidents in Oman:

The cost of accidents in Oman is calculated on two different parameters. The first parameter is the same as used in Qatar, the construction project's values. The second parameter used to estimate the cost of accidents in construction in Oman is based on the raw data obtained from the Public Authority of Social Insurance (PASI). The construction project's data for the year 2015-2016 shows that the total value of different types of development projects was US$ 163,568 Million (Umar, 2017). If it is assumed that that the cost of accidents in the USA, UK, and Oman are comparable and the average values of the costs of accidents from the USA and UK are applied in Oman, the total costs of accidents will be US$ 12,268 Million as shown in figure 4.2.

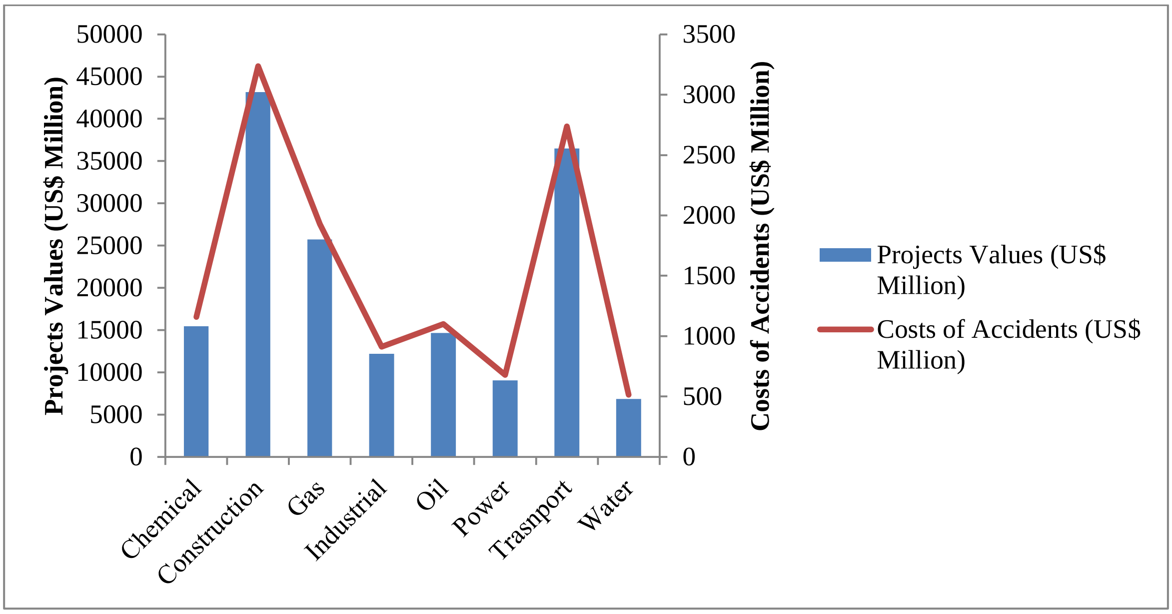


Figure 4. 2: Costs of Accidents in Oman

The second estimate is based on the data obtained from the PASI in Oman which registered only Omani citizens in the system. The data shows that a total of 495 cases of work-related injuries were disbursed. The total number of active insurees by the end of 2017 was 233,859 (PASI, 2017). The causes of these injuries and types of benefits given for these injuries are given in table 4.5 and table 4.6.

Table 4. 5: Causes of Injuries Cases Disbursed by PASI

Cause of Injury (Standard PASI Classification)	**Number of Injuries**	**Percentage (%)**
Traffic Accident	154	31.11
Slipping and Falling of Worker	133	26.87
Falling Object on the Injured	43	8.69
Getting Crammed Between Solid Objects	43	8.69
Crashing With Other Objects	31	6.26
Falling from the Top	30	6.06
Collision With Moving Machines	10	2.02
Others	51	10.30
Total	**495**	**100**

Table 4. 6: Types of Benefits Disbursed Against Injuries Cases by PASI

Types of Benefits Disbursed (Standard PASI Classification)	**Number of Cases**	**Percentage (%)**
Work off or Days off Allowance due to Work-related Injury	399	80.61
Work-Related Injury Lump Sum Compensations Partial Disability with less than 30%	46	9.29
Partial Disability Pension from (30%) to less than (100%)	25	5.05
Occupational Death Pension	21	4.24
Full Disability Pension (100%)	4	0.81
Total	**495**	**100.00**

The costs of these accidents are calculated based on the average cost (~US$ 25,450) of an accident derived from the average costs of accidents in the USA, UK, AUS, and SA. The assumption is that the accident cost in Oman could not be the same as the costs of accidents in the USA, UK, AUS, and SA. Based on this assumption, the cost of these accidents is estimated at US$ 12.59 Million. The amount of compensation disbursed by the PASI in 2017 against these cases (~495) is equal to US$ 8.16 Million or US$ 151,135 per injury (table 4.7). This can be classified as the indirect cost of the injury as this amount doesn’t include direct costs such as medical treatment etc. The comparison of this indirect cost of injury in Oman (~US$ 151,135/injury) with indirect of the accident in SA (~US$ 16,400), reflects that the indirect cost of an injury in Oman is almost 10 times more than the cost of an injury in SA. To determine the direct costs of these accidents, the equation developed by Haupt and Pillay (2016) was used (equation No.1). The assumption here is that the direct costs of an accident are half of the indirect costs. Thus for the calculation of the total costs of an accident in Oman, the direct costs are considered as US$ 75,567 per injury.

Table 4. 7: Types of Expenditure against Work-Related Injuries

Type of Expenditure	Year			
	206		2017	
	Amount (US$, 000)	% of Total Expenditure	Amount (US$, 000)	% of Total Expenditure
Full Occupational Disability Pensions	449.93	6	533.16	6.5
Partial Occupational Disability Pensions	975.29	12.9	1141.74	14
Occupational Death Pensions	4379.71	58.1	4665.80	57.2
Work-Related Injury Lump Sum Compensation	314.69	4.2	332.90	4.1
Daily Allowance in Case of Work-Related Injury	1422.63	18.9	1487.65	18.2
Total Expenditures Against Work-Related Injuries and Occupational Diseases	**7542.26**	**100**	**8161.25**	**100**

The total cost of an accident in Oman is thus estimated at US$ 415,620, which is 16 times more than the average costs of an accident in the USA, UK, SA, and AUS (~US$ 25,450). The total costs of an accident in Oman result in an economic burden of US$ 205.73 Million per year on the Omani economy.

The next section presents the results and analyses of the cost of accidents in Saudi Arabia.

4.3.3 Cost of Accidents in Saudi Arabia:

The costs of accidents in Saudi Arabia are calculated based on two methods, which are a) the values of the total projects in different sectors in Saudi Arabia and using a cost of accidents ratio which is 7.5% of the value of the projects; and b) the number of different types of accidents using an average obtained from reliable sources and using the average costs of accidents determine from the costs of accidents in USA, UK, SA, and Australia. The values of the different types of projects from 2015 to 2018 was obtained from the Venture Onsite website, which is of the leading organization tracking the construction projects across the Middle East and Africa region for more than 15 years. The contracts awarded in different sectors in Saudi Arabia are shown in figure 4.3 (Venture Onsite, 2018). To determine the costs of accidents in the development projects in Saudi Arabia, the average percentage (~7.5%) as the costs of accidents are used. The total costs of the accidents determined based on this principle are given in table 4.8. Since, in this method, the costs are dependent on the value of the projects, therefore as the value of the projects reduces the costs of accidents reduced as well. It can be clearly evident from table 4.8 that the costs of accidents in 2018 are less than the costs of accidents in 2015. This doesn't represent that the safety performance in 2018 has been improved compared to 2015. But the fact is that the values of the project are less in 2018 than in 2015. This was due to the economic conditions of the country which is heavily reliant on oil and gas earning. The dip in petroleum prices has also affected the development projects not only in Saudi Arabia but across the GCC.

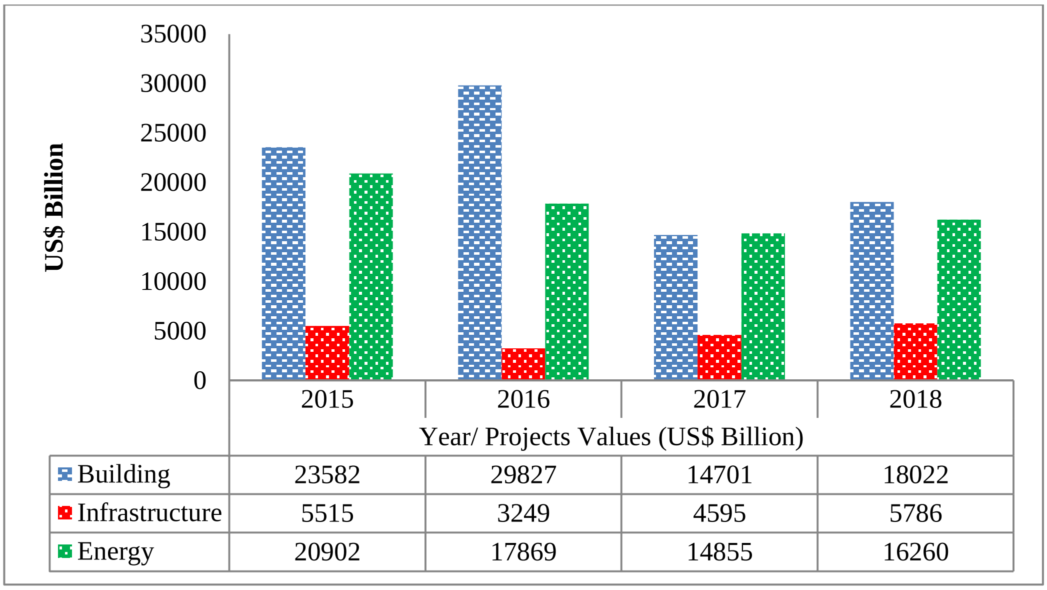


Figure 4. 3: Contracts Awarded During 2015-2018 in Saudi Arabia ((Venture Onsite, 2018)

Table 4. 8: Costs of Accidents in Different Sectors of Saudi Arabia

Sector	Year							
	2015		2016		2017		2018	
	Projects Values (US$ Billion)	Costs of Accidents (US$ Billion)	Projects Values (US$ Billion)	Costs of Accidents (US$ Billion)	Projects Values (US$ Billion)	Costs of Accidents (US$ Billion)	Projects Values (US$ Billion)	Costs of Accidents (US$ Billion)
Building	23582	1768.65	29827	2237.025	14701	1102.575	18022	1351.65
Infrastructure	5515	413.625	3249	243.675	4595	344.625	5786	433.95
Energy	20902	1567.65	17869	1340.175	14855	1114.125	16260	1219.5
Total	**49,999**	**3749.925**	**50,945**	**3820.88**	**34,151**	**2561.33**	**40,068**	**3005.1**

In the second method of estimating the costs of accidents in Saudi Arabia, the raw data was obtained from the General Organization for Social Insurance (GOSI), Saudi Arabia. The only accidents resulting in injuries, data that is available on the website was for the third quarter of 2018. Since the data for the whole year was not available; the numbers of different types of accidents were multiplied by 4 considering that GOSI divides one year into four quarters and assuming that the numbers of accidents in other quarters of 2018 were the same. This data is presented in table 4.9 (GOSI, 2018). The total number of accidents resulting in injuries or deaths in 2018 was estimated at 31,104. The average costs of one accident determined from the data obtained from the USA, UK, SA, and AUS were US$ 25,450. Thus the total costs of these accidents will result in a burden of US$ 791.59 Million to the Saudi economy. If the costs of these accidents are estimated based on the average costs of an accident in Oman (~US$ 415,620), this will result in a total cost of US$ 12927.44 Million.

Table 4. 9: Different Types of Accident in Saudi Arabia in 2018 (GOSI, 2018)

Office name	Third Quarter Data (2018)				The Whole Year Data (2018)			
	Injuries distribution in the private sector by recovery situation				Injuries distribution in the private sector by recovery situation			
	Cured Without Disability	Cured With Disability	Death	Under recovery	Cured Without Disability	Cured With Disabilit y	Death	Under recovery
Riyadh Office	864	182	7	612	3 456	728	28	2 448
Al Qassem Office	47	9	1	116	188	36	4	464
Hail Office	6	0	1	17	24	0	4	68
Al Kharj Office	0	1	0	26	0	4	0	104
Makkah/Jeddah Office	793	59	1	657	3 172	236	4	2 628
Makkah Office	319	24	3	137	1 276	96	12	548
Madinah Office	199	35	0	332	796	140	0	1 328
Tabouk Office	28	2	0	43	112	8	0	172
Al Taif Office	60	2	0	57	240	8	0	228
Yanbu Office	29	11	0	45	116	44	0	180
Eastren Region Office	1 181	23	2	504	4 724	92	8	2 016
Ahsa Office	197	7	1	188	788	28	4	752
Al Jouf Office	0	0	0	1	0	0	0	4
Jubail Office	228	17	0	127	912	68	0	508
Hafer Al-Batin Office	0	0	0	8	0	0	0	32
Northren Borders Office	1	3	0	2	4	12	0	8
Assir Office	29	4	0	305	116	16	0	1 220
Jazan Office	2	1	0	140	8	4	0	560
Al Baha Office	6	0	0	24	24	0	0	96
Najran Office	12	4	0	20	48	16	0	80
Bisha Office	1	2	0	11	4	8	0	44
Total	**4,002**	**386**	**16**	**3,372**	**16,008**	**1,544**	**64**	**13,488**

Similarly, the statistics published by the GOSI as shown in table 4.10, show that in the third quarter of 2018, a total of US$ 13.44 Million against the disabilities or deaths caused by accidents at the workplace (Table 8). The total number of disabilities (~386) and deaths (~16) in the same period were 402. Thus the indirect costs per accident which result in disability or death can be therefore estimated at US$ 33,433. Although this cost as an indirect cost is comparatively low than the indirect cost of the accident in Oman (~US$ 151,135), however, it is still double the indirect cost of the accident in SA (~US$ 16,400). The total cost of an accident in Saudi Arabia is estimated using equation No.1, assuming that the direct costs of accidents are half of the indirect costs. Thus, for this calculation, the direct costs of the accident are assumed as US$ 16,716. The total costs of an accident in Saudi Arabia are thus estimated at US$ 91,940. If the rate of disabilities and deaths arising from accidents in other quarters of the year will be the same, then the total number of such accidents could be 1,608 (= 4 x 402). The total burden of these accidents on the Saudi economy will be therefore US$ 147.84 Million per year. This is important to note that this amount could be more than what is estimated here as there are still cases (~3,372) in the same quarter which are still under treatment. Overall, the disabilities and deaths in the same quarter represent 9.12% of the total treated cases. If the same percentage of disabilities and deaths is applied to cases that are still under treatment, there will be a further of 308 cases that could end with disabilities and deaths. The total economic burden on the economy in one year from all these accidents will reach US$ 261.11 Million.

Table 4. 10: Benefits against Disabilities and Deaths Arising from Accidents (GOSI, 2018)

Third Quarter 2018	Occupational Hazards Benefits																							
	Monthly Benefits												*lump sum*				*Marriage grant*				*Death Grant*			
	Partial Disability				Full Disability				FAMILY MEMBERS															
Office name	**Saudi**		**Non-Saudi**		**Saudi**		**Non-Saudi**		**Saudi**		**Non-Saudi**		**Saudi**		**Non-Saudi**		**Saudi**		**Non-Saudi**		**Saudi**		**Non-Saudi**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Riyadh Office	274,498	9,875	324,307	368	94,923	0	174,478	0	483,271	1,159,190	87,506	966,212	173,870	59 729	1,739,601	1,614,113	0	0	0	3,375	10,000	11,667	0	0
Al Qassem Office	11,948	0	1,275	0	23,786	0	0	0	88,591	171,836	1,286	4,814	49,825	0	119,306	0	0	0	0	0	0	0	0	0
Hail Office	19,369	0	0	0	0	0	0	0	86,934	103,789	0	700	0	0	0	0	0	0	0	0	0	0	0	0
Al Kharj Office	7,037	0	0	0	0	0	0	0	37,617	104,084	0	0	0	0	720	0	0	0	0	0	0	0	0	0
Makkah/Jeddah Office	132,949	0	12,769	0	42,242	2,976	10,107	0	307,479	826,711	4,340	45,063	4,839	0	1,144,055	0	0	30,429	0	0	0	0	0	0
Makkah Office	22,156	0	1,200	0	14,231	0	0	0	141,429	356,219	7,479	8,563	50,000	0	385,542	300,000	0	0	0	0	0	0	0	0
Madinah Office	32,320	0	4,058	0	2,994	0	0	0	102,156	230,865	1,258	4,566	0	0	147,723	29,400	0	0	0	0	0	0	0	0
Tabouk Office	10,487	0	2,924	0	7,476	0	0	0	41,241	79,053	0	0	0	0	20,463	0	0	0	0	0	0	0	0	0
Al Taif Office	6,267	0	0	0	2,976	0	0	0	25,542	196,157	0	750	0	0	14,640	0	0	0	0	0	0	0	0	0
Yanbu Office	26,132	0	0	0	11,976	0	0	0	53,897	196,036	0	1,359	83,290	0	27,795	0	0	0	0	0	0	0	0	0
Eastern Region Office	325,209	0	8,594	0	94,819	0	0	0	416,761	1,377,313	3,734	25,679	658,025	0	151,642	0	0	37,969	0	0	0	0	0	0
Ahsa Office	222,521	0	1,425	0	50,702	0	0	0	379,032	1,164,342	1,089	10,355	102,723	0	112,230	0	0	44,571	0	0	0	0	0	0
Al Jouf Office	6,319	0	0	0	15,480	0	0	0	40,955	77,000	0	0	0	0	5,997	0	0	0	0	0	3,333	0	0	0
Jubail Office	107,483	0	3,055	0	49,813	0	0	0	177,848	494,796	2,800	17,781	0	0	52,263	165,000	0	6,210	0	0	0	0	0	0
Hafer Al-Batin Office	5,709	0	0	0	14,607	0	0	0	30,983	91,274	0	1,592	0	0	0	0	0	6,750	0	0	0	0	0	0
Northren Borders Office	5,878	0	0	0	0	0	0	0	41,991	81,489	0	0	0	0	7,588	0	0	0	0	0	0	0	0	0
Assir Office	24,340	0	0	0	17,976	0	0	0	212,016	393,474	1,035	518	0	0	60,870	0	0	0	0	0	0	10,000	0	0
Jazan Office	28,541	0	0	0	4,331	0	0	0	111,207	267,167	0	4,835	0	0	2,415	0	0	0	0	0	0	0	0	0
Al Baha Office	18,281	0	0	0	5,250	0	0	0	28,319	90,020	0	1,150	0	0	0	0	0	0	0	0	0	0	0	0
Najran Office	20,794	0	600	0	13,234	0	0	0	83,757	190,666	0	397	0	0	0	0	0	0	0	0	0	0	0	0
Bisha Office	2,570	0	0	0	0	0	0	0	43,141	101,510	397	1,695	0	0	0	0	0	0	0	0	0	0	0	0
Dawadmi Office	0	0	0	0	0	0	0	0	12,864	51,498	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**1,310,809**	**9,875**	**360,207**	**368**	**485,815**	**2,976**	**184,585**	**0**	**2,947,032**	**7,804,486**	**110,925**	**1,096,030**	**1,122,571**	**59,729**	**3,992,848**	**2,108,513**	**0**	**125,929**	**0**	**3,375**	**13,333**	**21,667**	**0**	**0**
Monthly Benefits	**14,313,106**												**Lump Sum + Marriage + Death Grants:**				**7,447,965**							
Total Benefits for One Quarter	**42,939,318.66**																							
Grant Total	**42,939,318.66 + 7,447,965 = 50,387,283 Saudi Rials = US$ 13,436,608.80 or US$ 13.44 Million**																							

Table 4. 11: Benefits against Disabilities and Deaths Arising from Accidents (GOSI, 2018)

4.4 Heat Stress:

To ascertain the effect of heat stress on construction worker's safety performance, a total of 623 accidents took placed in a highway project were analyzed. This was the accident data obtained from a local project to determine the causes of accidents as discussed in section 4.2. A total of 20 workers involved in these accidents were interviewed. The description of the interviewees is given in figure 4.4. The results and analyses of accidents and the interviews are discussed separately in the next sections.

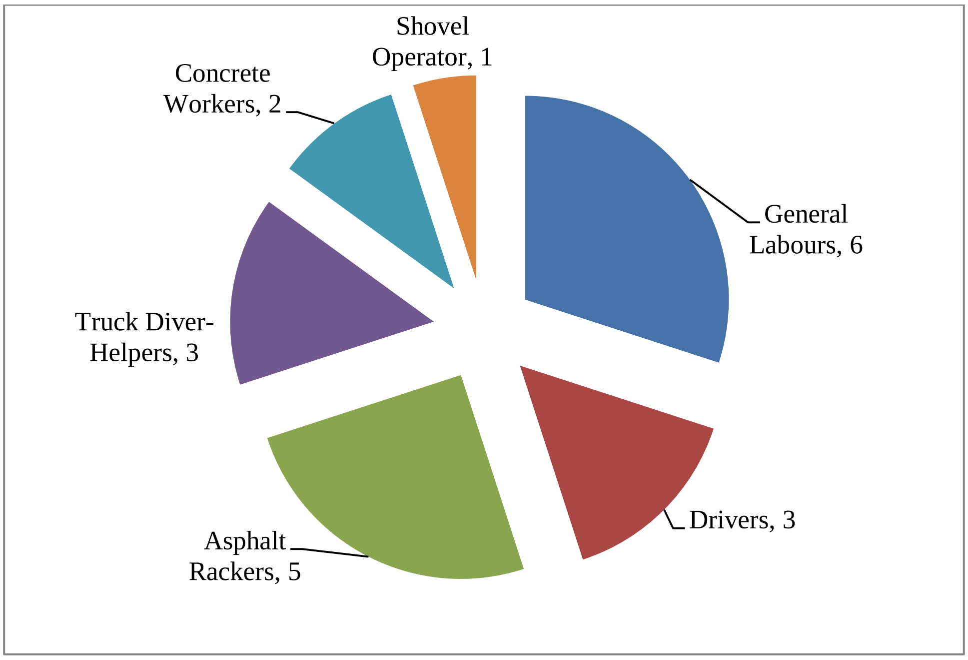


Figure 4. 4: Description of Interviewees

4.4.1Trends of Accidents in Selected Project:

Initially, the accidents provided by the construction organizations' health and safety team were assessed and classified into different root causes using table 4.1. This model identified four categories of "Equipment / Materials", "Worker", "Environment" and "Management" as the main cause of accidents. By using this model it has been revealed that a significant proportion of accidents (41 percent) arise from the "Worker". Furthermore, it is found that the "Management" factor contribution is 31%, Equipment/Materials contribution is 14% and the Environment contribution is 12%. Since the human factor is one of the main causes of these accidents, thus to understand this factor properly and to develop a relationship with the stress, these accidents were arranged according to their time and day on which they occurred. The results are shown in figure 4.5. The result shows that the work on the project was carried out on a 24 hours basis. Clearly, the number of accidents has increased gradually from 10:00 to 17:00, whereas a decline in the number of accidents can be observed after 17:00. This has a direct relationship with the temperature as in Oman; the temperature from 10:00 to 17:00 is normally high compared to the other time of the day. A slightly high number of accidents are also observed in the early morning (3:00 – 6:00) and nighttime (20:00 – 24:00). This may have no relationship with heat stress but several reasons for example drowsiness of workers and low light arrangement at the workplace. A huge number of accidents (= 32) were also observed on Saturday at 16:00 – 17:00, which will, of course, have a relationship with the heat stress, but also Saturday is the first day of the week where the work started for all private sectors.

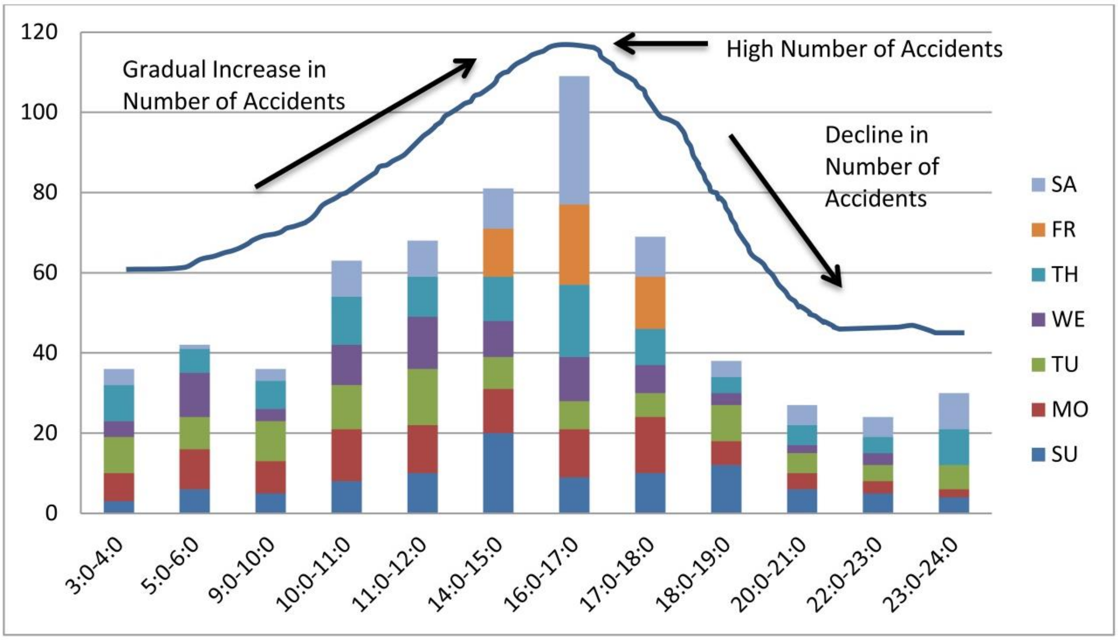


Figure 4. 5: Day and Time of Different Accidents in the Project

Similarly, to answer the question of what time the severe accidents happened on this project, an analysis of different types of accidents involving injuries with the time as they happened was performed. The result shown in figure 4.6 indicates that more severe accidents (MTI) took place around 10:00 to 18:00. The maximum numbers of different types of accidents involving injuries were from 11:00 to 17:00. A slight reduction is observed from 18:00 – 19:00 which could be because of possible worker shift change while a minor increase can be observed from 19:00 to 24:00.

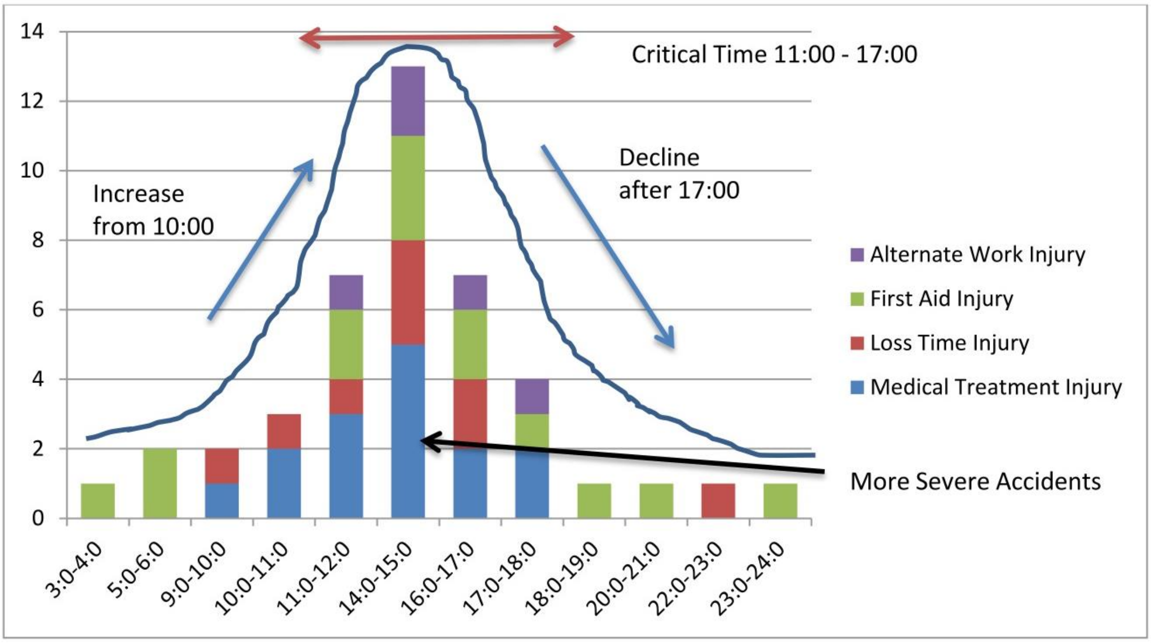


Figure 4. 6: Accidents Involving Injuries and their time

Both the analysis of the accidents showed in Figures 4.5 and 4.6 shows that the majority of accidents in the project happened during day time from 11:00 to 17:00. The direct impact of the heat stress, therefore, cannot be ignored due to the fact that the project is situated in the area which has the hot climatic condition and the time at which the accidents (11:00 to 17:00) happened normally has the highest temperature.

The results and analyses of the face-to-face interview held with some of the workers involved in these accidents are given in the next section.

4.4.2Results and Analyses of Semi-Structured Interview:

All the interviewees agreed that they were tired enough on the day and time of accidents. An interviewee who was a general worker stated that he was sick by fever on the day when he committed the accident. Most of the interviewees answered that the weather was very hot on the day and time when the accident happened. The majority (>80%) of the workers reported the hot climate as one of the main causes of the accidents. When asked with the question that how they protect themselves from direct heat, two interviewees responded that they used to keep a wet piece of cloth to cover their head under their safety helmet. Two of them responded that they used to go to the shadow area (if available at the site) if they felt more tired and exhausted with the heat. Three interviewees reported that in case they felt tired by excessive heat they used to remove their helmet and shoes and loosen their uniform to relax. Other respondents were pointing out the non-availability of resources such as water for drinking and washing. Some of them reported that they have to work for extended hours due to the shortage of workers and work pressure. Similarly, when the interviewees were asked the question of whether they liked to work for overtime, all of them answered with a yes. Few of them justified this with the reasons stating that it is important for them to work for overtime as this is the only way they can get more financial benefits and support their family back in their home countries.

Two interviewees who were dumper drivers reported that it is difficult to take day time break in the summertime as their duty is to supply the required materials to the workplace and if they were late, it affected the pace of the work. When interviewees were presented with the question at what time they preferred to work, fourteen (70%) out of twenty answered that they would prefer to work at night during summer. All workers reported that they don’t have any such incentive from the company which would help them to protect excessive heat exhaustion.

Participants were also asked questions on their sleeping habit as this can impact on their work performance and vice versa (Yi and Chan, 2016). Ten (50%) out of twenty reported that they normally sleep for five hours daily, six (30%) reported that they sleep from 5-6 hours daily and the remaining four (20%) reported that they normally sleep around 7 hours. This reveals that the majority of the participants suffer from sleep deprivation and thus their performance at work would be affected as the sleeping habit has a direct link with the body's blood pressure (Rees et al., 2013). The exposure to excessive heat further affected their body performance such as blood pressure and thus increases the possibility that the workers would not be able to take the right decision when dealing with risky activities.

The next section presents the results of the physical parameter that include the Body Mass Index and Blood Pressure of the same workers involved in the accidents under consideration.

4.4.3 Result and Analyses of BMI and blood pressure:

The results of the BMI calculation show that the BMI of only four participants (20%) was in the range of normal healthy range. The BMI of 12 out of 20 participants (60%) was in the range of overweight while four participants (20%) were obese. There was no participant who was underweight as per BMI value. The mean value of the BMI of the participants was 28.25$\pm$2.86. The details BMI of the entire participants are shown in table 4.11. The results further reveal that the participants classified as overweight and obese were above 25 years. The mean value of the age of the participants was 38.15±8.44. Descriptive analyses were also conducted considering the age groups of the respondents. The mean of the BMI of the age group “21-30” is 2, while the mean of the BMI of the age group “51-60” is 4. This means that the latter group BMI is highly affected by the age as compared with the first group (table 4.12). Similarly, the statistical results presented in the table show that there is however no significance when the age groups of the respondents were compared with their BP values ($p > 0.05$) using one way ANOVA test. A significant relationship ($p < 0.05$) was however observed between the age group of the respondents and the BMI classification (table 4.13). The whole picture of the participant’s age, BMI, BP, classification, means values and significance are presented in table 4.11, 4.12, and 4.13. The results of this study further reveal that the average DBP of all the participants was equal to 84±6.58 (mmHg). Similarly, the average SBP of all the participants was calculated at 136±8.27 (mmHg) as mentioned in table 4.11. The results further reveal that 40% (8 participants) blood pressure was more than the threshold and the fall under the hypertension values.

Table 4. 12: Result of BMI and its Classification

Participants	Age	BMI	Classification	Criteria	SBP (mmHg)	DBP (mmHg)	Classification	Criteria
1	24	24.5	Normal	BMI = 0 - 18.5 = Underweight BMI = 18.5 – 25 = Normal BMI = 25 – 30 = Overweight BMI = 30 and above = Obese	120	79	Normal	Hypertension if SBP = 140 or higher and DBP = 90 or higher
2	39	27.8	Overweight		133	80	Normal	
3	41	29.6	Overweight		128	78	Normal	
4	49	29.5	Overweight		137	82	Normal	
5	22	24.0	Normal		130	80	Normal	
6	33	27.9	Overweight		131	80	Normal	
7	51	33.2	Obese		143	92	Hypertension	
8	46	28.3	Overweight		142	90	Hypertension	
9	46	31.3	Obese		138	82	Normal	
10	43	29.1	Overweight		144	93	Hypertension	
11	28	24.7	Normal		122	78	Normal	
12	36	26.3	Overweight		134	79	Normal	
13	48	32.6	Obese		150	94	Hypertension	
14	37	25.9	Overweight		145	90	Hypertension	
15	40	28.3	Overweight		143	92	Hypertension	
16	39	27.1	Overweight		136	77	Normal	
17	26	24.1	Normal		125	75	Normal	
18	45	33.2	Obese		144	93	Hypertension	
19	34	29.2	Overweight		133	80	Normal	
20	36	28.4	Overweight		142	90	Hypertension	
Mean ± SD	**38.15±8.44**	**28.25±2.86**			**136±8.27**	**84±6.58**		

Table 4. 13: Descriptive Analyses of Different Age Groups with BMI and BP of the Participants

Description		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
BMI	21-30	4	2.0000	0.00000	0.00000	2.0000	2.0000	2.00	2.00
	31-40	8	3.0000	0.00000	0.00000	3.0000	3.0000	3.00	3.00
	41-50	7	3.4286	.53452	.20203	2.9342	3.9229	3.00	4.00
	51-60	1	4.0000					4.00	4.00
	Total	20	3.0000	.64889	.14510	2.6963	3.3037	2.00	4.00
BP	21-30	4	1.0000	0.00000	0.00000	1.0000	1.0000	1.00	1.00
	31-40	8	1.3750	.51755	.18298	.9423	1.8077	1.00	2.00
	41-50	7	1.5714	.53452	.20203	1.0771	2.0658	1.00	2.00
	51-60	1	2.0000					2.00	2.00
	Total	20	1.4000	.50262	.11239	1.1648	1.6352	1.00	2.00

Table 4. 14: One Way ANOVA Results Based on Age Groups, BMI, and BP

Description		Sum of Squares	df	Mean Square	F	Sig.
BMI	Between Groups	6.286	3	2.095	19.556	.000
	Within Groups	1.714	16	.107		
	Total	8.000	19			
BP	Between Groups	1.211	3	.404	1.799	.188
	Within Groups	3.589	16	.224		
	Total	4.800	19			

The next section presents the results and analyses of the qualitative study related to occupational safety and health regulations.

4.5 Occupational Safety and Health Regulations:

To compare the occupational safety and health regulations of GCC countries which selected countries which display an improved safety performance, Oman's regulations were selected from the GCC side and were compared with the regulation enforced in the USA, UK, AUS, and SA. As discussed in Chapter 3, the key regulations that cover fall protection; hazard communication standard related to chemicals; scaffolding; respiratory protection; control of hazardous energy; ladders; powered industrial trucks; training Requirements; machinery and machine guarding; and eye and face protection were initially considered. Since the purpose was to compare Oman's regulations with the regulations of some of the advanced countries, thus the comparison was only kept to the first three items including fall protection; hazard communication standard related to chemicals, and scaffolding was selected. The selection of these items and their regulations was based on the understanding that there is a high level of application in the construction industry. The current Occupational Safety and Health Regulation in Oman was introduced in 2008 through the Ministry of Manpower, in Oman.

The next section compared fall protection regulations applicable in Oman with USA, UK, AUS, and SA.

4.5.1 Fall Protection:

Statistics for the year 2016 shows that 38.7 fatalities in construction in the USA resulted from 'fall from a height' despite the fact that detailed regulations which cover 'fall protection' do exist in the USA. There are a total of 25 articles in fall protection regulations

(1926.502) enforce in the USA which addresses a variety of issues related to fall protection (Fall Protection, 1926). Similarly, there is a separate law in the UK known as “The Work at Height Regulations 2005” which has a total of 19 main articles, supported by a number of sub-articles and a total of eight schedules (The Work at Height Regulations, 2005). The Australian Code of Practice on how to manage the risk of falls at workplaces is an approved code of practice under section 274 of the Work Health and Safety Act (Code of Practice, 2018). This code of practice consists of 10 chapters and two appendices which deal with most of the issue related to fall protection. Similarly, in South Africa, the latest ‘Work at Height’ regulations came into force in 2013 (Occupational Safety and Health (Work at Height) Regulations, 2013). There are a total of six schedules, supported by a number of main and sub-articles. In Oman, fall from a height appears to be one of the main causes of accidents in different sectors as discussed in chapter two; however, there are no specific regulations that cover this cause of accidents in detail. The only regulations which look into the fall from height are the Regulation of Occupational Safety and Health, issued by the Ministry of Manpower in 2008 (MD, 286/2008). To be more specific the terms ‘fall from a height’, ‘fall from height’ or ‘fall from’ are not used in this regulation at all. The terms ‘fall’ and ‘falling’ are, however, used 11 times at different instances in the regulation. After carefully reviewing these 11 terms, it was found that two of the terms were out of the context of ‘fall from a height’. The remaining nine terms were associated with the preview of ‘fall from height’. The first identified term ‘fall’ was associated with the safety of the ladders and the regulation under Chapter 2 “General Arrangements” states that ‘ the metal network of the ladders must be tight enough so that not to allow any objects to fall’. Similarly, under article 22 of the same chapter of the regulation, it is stated that ‘workers must be protected from the hazards of falling, dropping objects, flying chips, sharp objects, caustic or hot liquids or any harmful materials. Similarly, four of the other identified terms are mentioned in chapter 4, under the ‘lifting tools’. Overall, the review of the whole regulation shows that, although it uses the terms fall, several times but don’t cover the full spectrum of the fall protection in detail. The regulation should be detailed in all aspects and should provide complete guidelines when dealing with any hazard related to fall protection. For instance, the Fall Protection regulation of USA (1926.502), under article 1926.502(b)(1) which is related to ‘guardrail system’ states that “top edge height of top rails, or equivalent guardrail system members, shall be 1.1 m plus or minus 8 cm above the walking/working level. When conditions warrant, the height of the top edge may exceed the 114 cm height, provided the guardrail system meets all other criteria of this paragraph”. Such through details were, however, not found in the ‘Occupational Safety and Health regulation’ applicable in Oman.

The next section describes the shortfall in Omani regulations related to hazard communication when compared with the regulations applicable in the USA, UK, AUS, and SA.

4.5.2Hazard Communication (Chemicals):

Hazard communication related to chemicals and other dangerous liquid was one of the top OSHA standards that were frequently cited in 2018. The current standards applicable in the USA came into force in March 2012 (Hazard Communication, 1910). The standards have a total of 10 main articles which are further supported by a number of sub-articles. The standards put the responsibility on the employers in majority cases either it pertains to the labeling on hazardous substances, employee training related to chemical use one site and maintaining the safety data sheets for incoming or outgoing shipments of hazardous chemicals. Similarly, there are comprehensive guidelines on the Classification of Hazardous Chemicals which falls under the Work Health and Safety Act and Regulations in Australia (GCHC, 2012). These guidelines consist of 34 pages and 12 sections supported by 10 tables and seven appendices. Overall, the guidelines cover all aspects of the classification of hazardous chemicals. The European Regulation No. 1272/2008 on classification, labeling, and packaging of substances and mixtures came into force on 20 January 2009 in all European Union Member States, including the UK (European Regulation No. 1272/2008). This Regulation is enforced by the Health and Safety Executive and local authorities in the UK. The regulation consists of 1389 pages, 62 articles which are further supported by a number of sub-articles, tables, and appendices. The regulation is available in 23 different languages. The regulation describes the labeling and storing criteria for hazardous chemicals in a more effective way and it is ensured through tables and examples that the readers understand the context easily. There are a number of Acts and regulations in South Africa which aim to control the hazards of industrial chemical as shown in table 4.14.

Table 4. 15: Acts and Regulations Controlling Chemical Hazards in South Africa

Regulation / Act	Authority / Requirement
National Environmental Management Act, 1998 (Act No.107 of 1998)	Authority: Department of Environmental Affairs The Act authorizes the Department of Environmental Affairs to prohibit or control certain substances or chemicals that pose threat to the environment and human health (i.e, asbestos).
Hazardous Substances Act, 1973 (Act No.15 of 1973)	Authority: Department of Health (DOH) The Act sets requirements on the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of hazardous substances.
Occupational Health and Safety Act No.85 of 1993	Authority: Department of Labour This regulation stipulates the Occupational Health and Safety standards for employers and users working with and around hazardous chemical substances
Hazardous Chemical Substances Regulations, 1995	Authority: Department of Labour These regulations apply to an employer or a self-employed person who carries out work at a workplace which may expose any person to the intake of Hazardous Chemical Substances at the workplace.

The review of the latest regulations (Hazardous Chemical Substances Regulations, 1995) shows that these regulations are complete in different aspects that cover topics related to chemical hazards. This includes information and training about chemical hazards, duties of persons who may be exposed to hazardous chemical substances, assessment of potential exposure; air monitoring; medical surveillance; respirator zone; record; handling of hazardous chemical substances; control of exposure to hazardous chemical substance; maintenance of control measures; prohibitions; labeling, packaging, transportation and storage; disposal of hazardous chemical substances; and offenses and penalties (HCSC, 1995). Overall these regulations have a total of 87 pages and eight annexures that have a detailed description of different articles of the regulations. Similarly, chemical hazards are also covered in a separate section (section 6) of the Occupational Safety and Health Regulation applicable in Oman (MD, 286/2008). Article 37 of the regulations enforce in Oman states “precautionary measures shall be adopted to protect workers against the risks of exposure to the chemicals which lead to the work environment such as gases and dust and the liquids and acids which they may include”. This article is further supported by 12 sub-articles that describe the precautions that need to be considered in relation to article 37.

Overall, the chemical hazards precautions in the regulation span over two pages that only provide the basic information.

The Omani regulations applicable to scaffolding are compared in the next section with USA, UK, AUS and SA regulations.

4.5.3 Scaffolding:

The term "scaffolding" was not found at all in the current 'Occupational Safety and Health regulations' enforced in Oman in 2008 (MD, 286/2008). The term "ladder" was, however, used at five different instances in the regulations which obviously cannot substitute the scaffolding. At the same time, in the United States, there are separate guidelines for scaffolding used in construction (OSHA:3150, 2002). The content of these guidelines includes general requirements for scaffolds (1926.451); specific Scaffold (1926.452); aerial lift requirements (1926.453); and training requirements (1926.454). Similarly, the Health and Safety Executive (HSE) in the UK provides the guidelines and checklist for the scaffold. In the UK it is a requirement of the Work at Height Regulations 2005 that unless a scaffold is assembled to a generally recognized standard configuration, such as 'National Access and Scaffolding Confederation (NASC) Technical Guidance (TG20) for tube and fitting scaffolds or similar guidance from manufacturers of system scaffolds, the scaffold should be designed by bespoke calculation, by a competent person, to ensure it will have adequate strength, rigidity, and stability while it is erected, used and dismantled.

The guidelines further state that at the start of the planning process, the user should supply relevant information to the scaffold contractor to ensure an accurate and proper design process is followed (HSE, Scaffold, 2019). The HSE guidelines also provide criteria for scaffold inspection. In this regard, the guidelines state that it is the responsibility of the scaffold user that the scaffold has been inspected following installation and at every interval of seven days. In Australia, the scaffolds are covered in Construction Work, Code of Practice (CWCP, 2018). These guidelines cover the full spectrum of the scaffold that includes Scaffold definition; Work health and safety duties; Managing risks; Before starting scaffolding work; Choosing a scaffold; Designing the scaffold; The system of work; Documentation; Competency and licensing; Inspecting scaffolds; and Types of scaffolds and scaffolding. The guidelines are supported by a number of diagrams and figures that explain different aspects of the scaffold in a more effective way. Similarly, the Construction regulations which came into force in 2017 in South Africa cover the scaffold (Construction Regulations, South Africa, 2014). These regulations made the contractor responsible for appointing a competent person in writing who must ensure that all scaffolding work operations are carried out under his or her supervision and that all scaffold erectors, team leaders and inspectors are competent to carry out their work. Similarly, the regulations state that any contractor using access scaffolding must ensure that such scaffolding when in use, complies with the safety standards of South Africa. The regulations further emphasize that the Scaffolds design must comply with South African National Standards (SANS:10085, 2004).

4.5.4 Status of International Labor Organization (ILO) Conventions in Oman:

It has been observed that Occupational Safety and Health has been of importance to the Omani government since 1970. Different regulations have been introduced to tackle the Occupational Safety and Health status effectively in different industries. Since its membership with International Labor Organization (ILO) in 1994, Oman has ratified four out of the eight core Conventions, namely the;

i. Forced Labour Convention, (C-29, 1930);

ii. Abolition of Forced Labour Convention, (C-105, 1957);

iii. Minimum Age Convention, (C-138, 1973);

iv. Worst Forms of Child Labour Convention, (C-182, 1999).

Oman still has to rectify the ILO some of the OS&H conventions including;

a. Occupational Safety and Health Convention, (C-155. 1981);

b. Occupational Health Services Convention, (C-161. 1985);

c. Promotional Framework for Occupational Safety and Health Convention, (C-187, 2006).

The next section presents the results and analyses of the study related to worker's health factors and body pain.

4.6 Construction Workers Health Factors:

This part of the research aimed to investigate the workers’ health profile considering the key health indicators such as BMI, blood pressure and heart rate. Body pain was considered part of this research as it has some impact on the worker's safety and productivity. As discussed in the methodology section, this research had three components including face-to-face interviews; measurement of MBI, blood pressure and heart rate and a pain experience questionnaire. A total of 30 volunteers were selected from one major projects handled by two major construction companies as a joint venture. The results and analyses of this part of the research are given in the next sections starting from the Demographic Information and BMI.

4.6.1 Demographic Information and BMI:

All the 30 workers who participated in this study were male while the majority of them were from India, followed by Pakistan, Bangladesh and then Siri Lanka as shown in table 4.15. The average age of the workers was 33.26 years ranging from 20 years to 51 years. The results of BMI indicate that there is no worker who can be classified as underweight (BMI≤18.5). The average value of BMI was 27.32 which indicates that the majority of the workers are overweight (BMI≥25). Overall, the BMI of eight participants (26.7%) was in the normal range (BMI = 18.5 – 25), 14 participants (46.7%) were found to be over weighted as per the result of their BMI (BMI = 25 – 30). The BMI of the remaining eight participants (27%) was greater than 30, thus classified as obese. It is clear from the results of the BMI that the majority (73.3%) of the construction workers are overweight or obese. Research conducted by Dua et al (2014) suggests that increased value of BMI being linked with prehypertension may advise that such individuals are at expanded exposure of progressing to direct hypertension. Although the percentage of overweight or obese (73.3%) seems to be alarming, however, it appears to be an issue in most of the construction industries globally. For instance, in Hong Kong, Netherlands, and Germany the percentage of overweight and obese in construction industries is 42.6%, 75%, and 63.7% respectively (Yi and Chan, 2016; Groeneveld et al., 2008; Claessen et al., 2009). The results show that the average sleeping hours of the participants is 4.5 hours. Research conducted by Lombardi et al. (2010), on daily sleep and risk of work-related injury interviewed 177,576 persons (ages 18–74) and estimated that annual injury rates/100 workers were 7.89 if the daily sleeping hours remains less than 5 hours. There have been growing evidence that short sleep duration is linked with many chronic disease outcomes, such as diabetes, hypertension, cardiovascular disease, obesity and other sicknesses which results into absences from work (Gottlieb et al., 2005; Gangwisch et al., 2006; Ayas et al., 2003; Di Milia and Mummery, 2009; Marshall et al., 2008; Singh et al., 2005; Westerlund et al., 2008). From the smoking habit, it was found that 12 participants (40%) have no smoking habit. 11 participants (36.66%) were classified and occasional smokers while 7 participants (23.33%) were daily smokers. Smoking is considered one of the main causes of high blood pressure and hypertension, thus for Prevention and treatment for both of them, quitting smoking is normally recommended (Daskalopoulou et al., 2015). The trade classification of all the participants is shown in figure 8.

Table 4. 16: Demographic Information of the Participants

Characteristic	Number	Min	Max	Mean ± Standard Deviation	Percentage
Age	30	20	51	33.26±8.95	-
BMI	30	22	33	27.32±3.17	-
Sleeping Hours	30	4.5	10.5	7.21±1.83	-
Smoking	--	--	--	--	--
No Smoking	12	-	-	-	40
Casual Smoking	11				36.66
Daily Smoking	7	-	-	-	23.33
Ethnicity	-	-	-	-	-
Indian	13	-	-	-	43.33
Bangladeshi	9	-	-	-	30
Pakistani	7	-	-	-	23.33
Siri Lankan	1	-	-	-	3.33
Working Experience in years	30	1	21	5.54±4.97	-

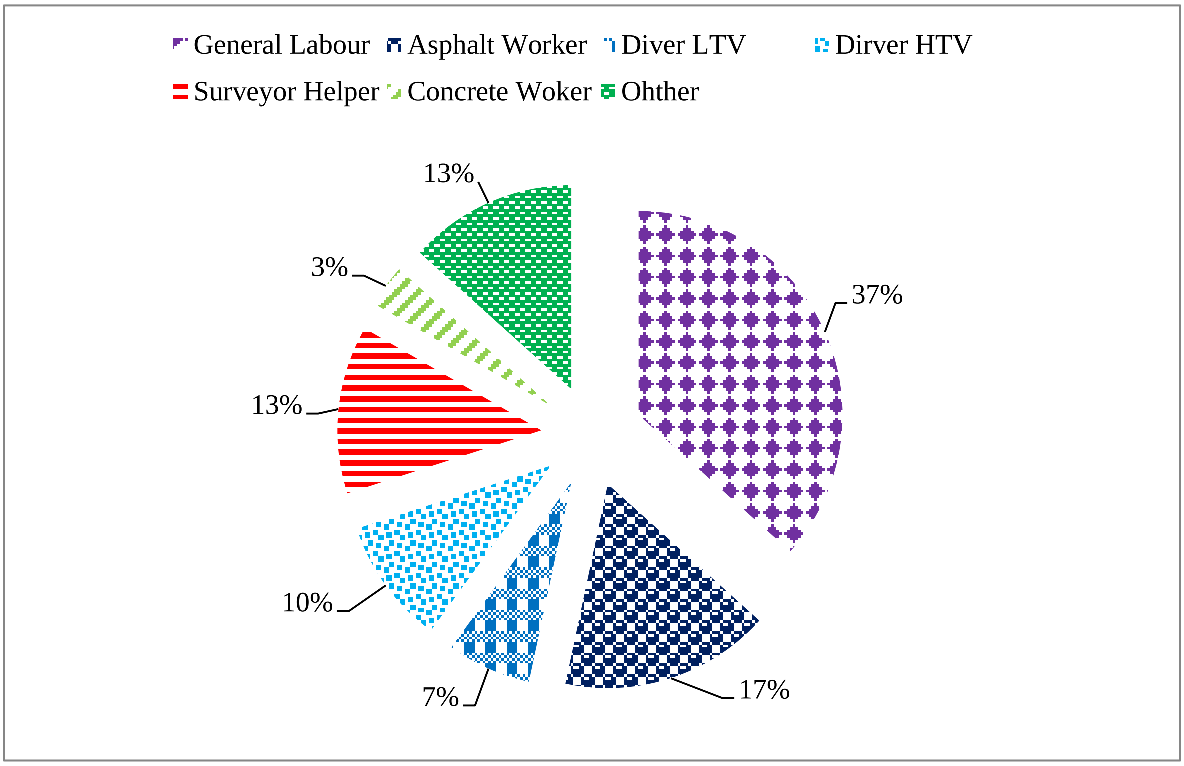


Figure 4. 7: Trade Classification of Participated Workers

The next section discusses the results and analyses related to the worker's blood pressure and heart rate.

4.6.2 Blood Pressure and Heart Rate:

The criteria described by Poulter et al., (2015) indicate that if a person having a blood pressure more than or equal to 140 mmHg SBP or more than or equal to 90 mmHg DBP is to be classified hypertension. Similarly, the American Heart Association classified the mean resting heart rate for adults is to be from 60 to 100 beats per minute (bpm), and for well-trained athletes, it is to be from 40 to 60 bpm (AHA, 2018). The results of this study reveal the average DBP of all the participants was equal to 78.3±14.7 (mmHg). Similarly, the average SBP of all the participants was calculated at 136.2±18.3 (mmHg). The results further reveal that 43.3% (13 participants) blood pressure was more than the threshold and the fall under the hypertension values. The average value of RHR was found at 78.5 bpm, ranging from 56 bpm to 113 bpm. While the RHR of some of the participants (6.66%) were lower and for one of the participant it was higher than the normal, however, it seems to be usual as indicated by the American Heart Association (AHA, 2018).

The results and analyses from the Musculoskeletal Pain study are presented in the next section.

4.6.3 Musculoskeletal Pain:

The questionnaire for the assessment of musculoskeletal pain was prepared in English, however, since none of the respondents were able to complete the questionnaire, thus assistance was provided to them for translation of the questions and to record their response on the questionnaire completely. This enabled all the respondents to complete the questionnaire. A total of 14 (46.60%) workers reported that they suffered from pain or discomfort in the last three months. The results indicate that most of the workers (13 out of 14) who reported to suffered from pain were 35 years or above 35 years old ($8 \geq 40$; $6 \geq 35 - 40$). The body areas which were frequently reported by the worker for the pain are shown in table 4.16 and the severity of the pain is presented in table 4.17. Lower back was one of the areas which were reported more frequently for the pain (39.4%). The average of the pain of 14 workers who reported pain or discomfort on a scale of 1 – 10 (1= very mild pain, 10 = unbearable pain) was 3.68±2.14.

Table 4. 17: Frequent Reported Areas for Musculoskeletal Pain

Area of Pain	Reported Frequency (%)
Neck	12.67
Shoulder	15.30
Lower Back	39.40
Leg	14.52
Knees	18.11

Table 4. 18: Severity of Musculoskeletal Pain

Severity of Pain	Mean ± Standard Deviation (SD)
Extreme Pain Over the Past 24 Hours	5.4±2.4
Slightest Pain Over the Past 24 Hours	2.3±2.0
Average Pain Over the Past 24 Hours	3.9±2.1
Present Pain	2.7±2.4

Statistical analysis shows that the sleeping habit was important in worker reported pain severity. The mean pain for workers with seven or more than seven hours of daily sleep hours (3.13 ± 2.1) was less than that of those with less than 7 hours of daily sleep (3.87 ± 1.97).

One of the main components of research objectives No.5 and 6 as discussed in section 3.3.5 of the research methodology section was to know the methods the workers used to treat the pain. The next section, therefore, discusses the results and analyses related to the treatment of pain.

4.6.4 Treatment of Pain:

The workers were inquired to indicate the approaches they implied to get relief from the pain. Figure 4.8 shows the methods reported by the workers who supper from pain. The use of pain killers (57%) was more common treatment adopted by these workers. Three out of fourteen workers (22%) reported that they just ignore the pain. The use of medical cream, massage and exercise were also reported by workers as a method of relief from pain.

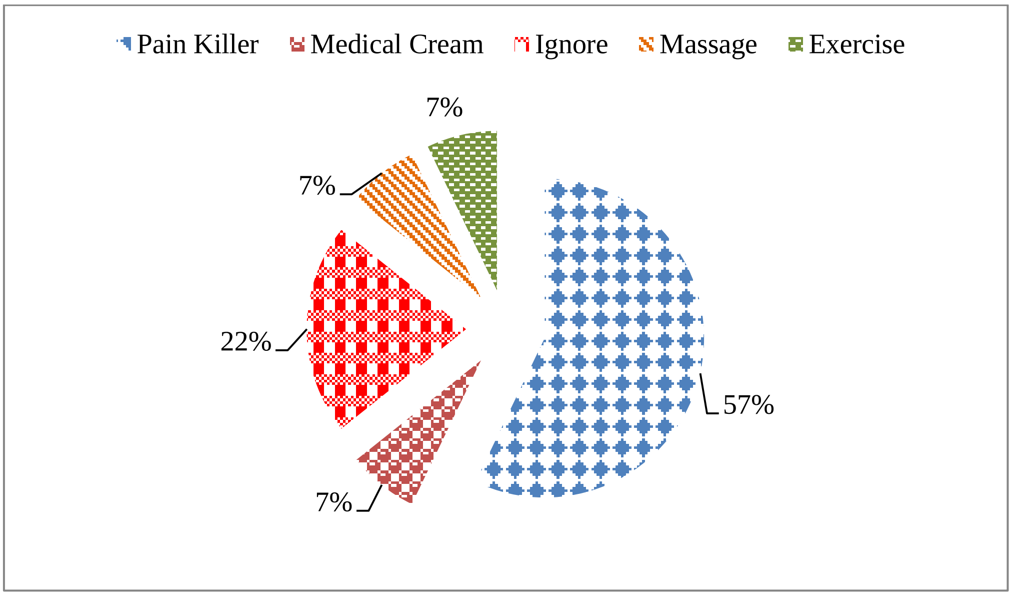


Figure 4. 8: Pain Relieving Methods

Apart from the treatment of pain, the questionnaire used (Appendix II) in this research also aimed to investigate the impacts of pain on the worker's daily life activities. The next section, therefore, discusses the results and analyses of the impacts of pain on workers' life.

4.6.5 The impacts of Pain on Workers Life:

To understand the impacts of musculoskeletal pain, workers were requested to rate the impact of pain on their daily life including mood, walking ability, work, relationships, sleep, and hobbies, on a five-point Likert scale ranging from 1 – 5 (1= strongly disagree; 5 = strongly agree). Descriptive analysis was carried out on the collected data in which mean and standard deviations were calculated. The mean score of the effect of pain on workers' productivity was 3.64 followed by sleeping habits (mean score = 3.5). This reveals that the pain is considered an important element by the workers which highly affect their productivity and sleeping habit (Table 4.18). One way ANOVA was applied to measure the significance of the age group of the workers on different elements of their daily life. The results, however, show that there is no significant relationship (table 4.19). Since there was no significant relationship obtained through the one way ANOVA test, the results of the descriptive analysis were considered important in relation to the impact of the pain on the worker's daily life. The mean score of all the parameters considered in the questionnaire (Appendix II) was greater than 2.5 (on a scale of 1 to 5) which means that all these parameters of the workers daily are affected by the body pain experienced by workers. The mean score of productivity (= 3.64) was on the top, therefore this parameter is ranked first.

A detailed discussion of the body pain and its consequences is provided in section 4.7.7 of this chapter.

Table 4. 19: Impacts of Pain on Workers Abilities

Parameters	N	Minimum	Maximum	Mean	Std. Deviation	Rank
Mood	14	1	5	3.36	1.550	3rd
Walking Ability	14	1	5	2.79	1.251	6th
Work Productivity	14	1	5	3.64	1.151	1st
Relationship With Partner, Friends, and Family	14	1	5	3.21	1.369	4th
Sleep	14	1	5	3.50	1.225	2nd
Hobbies	14	1	5	3.07	1.439	5th
Valid N (listwise)	14					

Table 4. 20: Results of One Way ANOVA-The Impact of Body Pain on Daily Life

Parameters		Sum of Squares	df	Mean Square	F	Sig.
Mood	Between Groups	10.006	1	10.006	5.662	.035
	Within Groups	21.208	12	1.767		
	Total	31.214	13			
Walking Ability	Between Groups	.149	1	.149	.088	.771
	Within Groups	20.208	12	1.684		
	Total	20.357	13			
Work Productivity	Between Groups	.381	1	.381	.272	.612
	Within Groups	16.833	12	1.403		
	Total	17.214	13			
Relationship With Partner, Friends and Family	Between Groups	.024	1	.024	.012	.916
	Within Groups	24.333	12	2.028		
	Total	24.357	13			
Sleep	Between Groups	1.167	1	1.167	.764	.399
	Within Groups	18.333	12	1.528		
	Total	19.500	13			
Hobbies	Between Groups	.720	1	.720	.330	.576
	Within Groups	26.208	12	2.184		
	Total	26.929	13			

Since the safety climate, part of the study was one of the major objectives of this research; therefore the results, analysis, and discussion of this part have been placed in the next chapter. The next section provides a discussion of the results and analysis presented in this chapter.

4.7 Discussion:

This section of the thesis is a discussion that aims to provide a fruitful discussion on the entire components except for the safety climate part of the research. The discussion on the safety climate is provided in chapter 5. The first part of the discussion discusses the causes of accidents. This part describes how the accidents were classified and then trace using the proposed accident tracing model. It is further supported by the discussion on how construction organizations could interpret the results obtained from the proposed tracing model. The second part of the discussion provides an extensive discussion of the costs of accidents in construction. It briefly outlines what were the costs of an accident in Qatar, Saudi Arabia, and Oman and how these costs compared with each other. The discussion on the importance of the costs of accidents is also outlined in this part. The heat stress and its effect on the construction worker's performance are discussed in section 4.7.3. A brief comparison of the results of heat stress is made with some international studies. The key challenges including overtime and compulsory afternoon break during summer are discussed in this section. The guidelines which could help to protect the construction workers from heat stress are also discussed in this part. Similarly, key components of the "Occupational Safety and Health Regulations" in Oman are discussed in the fifth part of the discussion section. The key limitations of current regulation along with the recommendation to improve the current regulation are outlined in this part. Construction worker health factors' are discussed in a separate section in which the results of the current study are discussed along with an emphasize on how a healthy worker could be more productive and safer. Similarly, the body pain experience of the workers is discussed under section 4.7.7. The results of the current study are compared with some international studies that reflect that body pain among construction workers is a global phenomenon that needs the attention of the decision-makers to develop strategies that could highlight the importance of musculoskeletal pain and how it can be effectively managed.

The next section provides a discussion on the results and analysis obtained from the causes of accidents.

4.7.1 Causes of Accidents:

It is important for construction organizations to know the causes of accidents in their projects so that they could develop strategies and guidelines to avoid such accidents in their future projects. This research classifies the construction accidents into main four categories known as "Alternate Work Injury (AWI)", "First Aid Injury (FAI)", "Loss Time Injury (LTI)", "Medical Treatment Injury (MTI)" and "Property / Equipment Damage". The main causes of these accidents are then associated with four main factors namely, "Equipment / Materials", "Worker", "Environment" and "Management". Each of these factors is supported by different statements that help to relate an accident to these factors as mentioned in table 4.1. The accident data collected from the main highway project in Oman was initially classified into different types of accidents and then was assessed against the statements appended in table 4.1 to trace the main causes of these accidents. The analysis of the results of these accident presented in table 4.4 suggest that a significant proportion of accidents (42%) arise from “Worker”. Furthermore, it is found that the “Management” factor contribution is 31%. Similarly, the results also suggest that the “Equipment/Materials” contribution is 14% and the “Environment” contribution is 13%. In relation to improving safety performance and reduce the number of accidents, this organization needs to focus on the workers as it raked as the highest cause of accidents in their project. Overall, whatever are the causes of accidents, remedial action has to be taken from management. These actions are not to be limited to blame and punish the individuals but have to consider the matter at the organization level. For instance, if a worker has committed an accident due to the reasons that the worker was under fatigue or stress or he has no experience to do a particular task, so in this case, the worker and management should share the responsibility. The worker should be able and free to share his condition with his supervisor, and his supervisor should be able to take necessary action considering worker conditions. If this is not happening in an organization, then the management needs to seriously think that why this is not happening in their organization. If the worker was not able to share his condition with his supervisor then this means that the worker is not empowered in that organization. This is something that has to be fixed by the management by ensuring that the workers in their organization feel empowered and that the workers feel free to raise their concerns. Overall, the model presented in this research is to trace the causes of accidents and to identify the main areas that organizations could improve to reduce accidents. Construction organizations should be able to interpret the result properly in the right direction. The next section provides a discussion on the costs of accidents in construction which was one of the research objectives of this project.

4.7.2 Costs of Accidents in Construction:

The improved safety performance could not be achieved until there is some investment in it. Owners or management of the construction organizations remains reluctant to spend money on safety as they ignored the consequences even the financial. One of the main factors which could motivate the owner and the management of the construction organizations to spend on the safety and health-related issue is the costs of accidents. When the top management or the owner will have a clear idea of the costs of accidents, they will be then prepared to spend on the preventive measure. The matter is not only associated with organizations but there is also a need for awareness at government level as how much their country's economy is affected by such costs which can be prevented by a small investment. This thesis estimates the costs of accidents arising from the workplace in GCC. The GCC construction market is grooming and provides jobs to millions of peoples both locally and internationally. The current status of safety and health of workers in this region has attracted the attention of media due to a number of world-renowned projects such as the FIFA world cup stadium in Qatar. Some reports indicate that the worker's deaths have already reached 1,200 and it may hit 4,000 deaths by 2022. In such a situation the estimate of the costs of accidents in this region may be helpful to motivate both the government and construction organizations working in this region to improve their safety performance. Three countries among the GCC including Qatar, Oman, and Saudi Arabia were selected to estimate the costs of the accidents. Different parameters were used to estimate these costs in this region. The average values of the cost of accidents based on the values of the project in the USA and the UK are calculated as 7.5%. First, the costs of accidents in Qatar, Oman, and Saudi Arabia are calculated based on this value (~7.5%) and the current projects in these countries. The results show that the costs of accidents on this principle are US$ 8,808 Million in Qatar, US$ 12,268 Million in Oman and US$ 3,005.1Million in Saudi Arabia. In the second method, the costs of accidents are calculated on the amount paid against injuries, disabilities, and deaths in Oman and Saudi Arabia. There were 75 deaths and one disability caused by work-related accidents in Qatar. The total expenditures of benefits caused by these deaths (~USD 4.31 Million) and disability (~1.37 Million), was US$ 5.68 Million which were translated into a total cost of accidents in Qatar as US$ 205,526. The amount of compensation disbursed by the PASI in 2017 against these cases (~495) is equal to US$ 8.16 Million or US$ 151,135 per injury, which is considered as indirect costs of the accident in Oman. The total costs of an accident in Qatar and Oman are then calculated considering the relationship between the direct and indirect cost of an accident. Based on this relationship the estimated costs of an accident in Qatar stand at US$ 205,526; while in Oman it is standing at US$ 415,620. The costs of accidents in Qatar (~US$ 205,526) and in Oman (~US$ 415,620) are nine times and 16 times more than the average costs of an accident in the USA, UK, SA, and AUS (~US$ 25,450) respectively. This translates into an economic burden of US$ 205.73 Million per year on the Omani economy. The available statistics related to compensation against injuries, disabilities, and deaths published by the government agency in Saudi Arabia, show that in the third quarter of 2018, a total of US$

13.44 Million against the disabilities or deaths caused by accidents at workplace. The total number of disabilities (~386) and deaths (~16) in the same period were 402. Thus the indirect costs per accident which result in disability or death can be therefore estimated at US$ 33,433. The total costs of an accident in Saudi Arabia are estimated at US$ 91,940. The economic burden of these accidents on the Saudi economy is calculated using ratio analysis between the amounts disbursed in one quarter and the number of disabilities and death in the same quarter. This method was applied as the data for the remaining quarters was not available. The total number of accidents resulting in disabilities and deaths are therefore estimated at 2,840 per year. The total costs of these accidents (2840 x 91,840 = 261.10 Million) put an economic burden of US$ 261.10 Million per year on the Saudi economy.

The next section of the chapter provides a discussion on the heat-stress and effect on construction workers.

4.7.3 The effects of heat stress on construction workers:

The analysis of accidents in the selected project presented in Figures 4.5 and 4.6 of chapter 4 suggests that the majority of the accidents in the project happened during day time from 11:00 to 17:00. The direct impact of the heat stress, therefore, cannot be ignored due to the fact that the project is situated in the area which has the hot climatic condition and the time at which the accidents (11:00 to 17:00) happened normally has the highest temperature. This finding was aligned with a number of studies conducted globally. For instance, a Research conducted in Spain by López et al. (2008) involving 1,630,452 accidents spanning over a period of 10 years (1990-2000), considered the time of these accidents and concluded that a larger number of accidents took placed at break time from 10:00 – 11:00 and 14:00 – 15:00. They further concluded that when workers eat and drink in the morning break and at lunchtime can increase the chances of committing an accident and the severity of such accidents could be more. It is worth mentioning that in Spain, the morning break is normally from 10:00 to 11:00, while the lunch break is from 14:00 to 15:00. Another study carried out by Wigglesworth (2006) in Australia considering the 750,000 compensation claims filed by workers during the period from 1968 to 1988, observed that the number of accidents was comparatively more in the mornings than the accidents in the afternoons. Since the accidents presented in this thesis are from a single construction project, thus due to the limitation of the data, this may not be enough to reach a more reliable conclusion that what is a more frequent time of the accident in construction in Oman.

It has been noted that hot conditions at construction sites especially in summer are also observed by the government agencies responsible for health and safety in the country. According to article 16 of the Occupational Safety and Health regulations, Oman; workers must not work at construction sites or in open and elevated areas from 12:30 pm to 3:30 pm during June, July, and August (OSHR, 2008). This regulation is widely published and enforced by the Ministry of Manpower, Oman, but still, the workers have not yet got the full benefits of the regulation. For instance, the workers should be able to use this time (12:30 pm to 3:30 pm) to take proper rest; however, in most construction sites, this does not happen. In figure 4.9, it can be seen that the workers are not working during the break time but they are taking rest on the ground and inside the scaffolding. The workers may have no alternative other than taking rest on ground and scaffolding which triggers an important safety hazard.

Figure 4. 9: Workers Taking Rest During Break Time on Ground and Scaffolding

From the analysis and results of the interview held with the workers, which is presented in section 4.42 of this chapter, it is revealed that heat stress has some impact on these workers' performance including safety performance. There are other factors that contribute to heat stress and one of them is the overtime. According to article 68 of Oman labor law, an employee may not be required to work for more than nine hours a day and to a maximum of 45 hours a week (OLL, 2003). Similarly, article 70 of the same law allowed a worker to work for overtime of 3 hours per day, up to a maximum of a total of 12 hours per day. The law also provides criteria on payment of overtime which covers both the overtime for day and night. The overtime should be given to a worker with his/her consent, which means that a worker can refuse to work for extra hours as overtime. However, this is not happening in reality. The first thing is that most of the workforce is coming from developing countries and they prefer to work for overtime so that they can support their family in a better way. Secondly, the companies would like to have the workers who can work for extra hours so that they can catch up with the progress and to avoid the hiring of additional workers. Thus in case a worker refused to overtime, it is most likely the company will not renew his contract and later the worker will be replaced by one who is willing to accept overtime.

Clearly, from the BMI results mentioned in section 4.43, indicate that the majority of participants (80%) are not in the healthy range value. Similarly, 40% of the participants based on the results of their SBP and DBP were classified as hypertension. There will be more possibility that such workers would be more affected by heat and thus their safety performance will not be the same as a worker who is classified as normal or healthy. The finding of this research related to BMI was somehow matching with similar research conducted in different parts of the world. For instance, a research conducted in Denmark reported the BMI of 147 blue-collar workers from a variety of professions including construction and observed that the BMI of 59% of the participants was more than 25 (Gupta et al., 2018). The mean value of the BMI of the selected participants was 26.4 ± 4.80. Similarly, the mean BMI of 932 construction workers in Hong Kong reported by Yi and Chan (2016) was 24.3 ± 3.70. Their reported BMI results further reveal that 2.8% of the participants were underweight, 36.1% were overweight and 6.5% were obese. The finding of similar research conducted on 314 male construction workers in the Netherland shows that based on the BMI results, 70% of the participants were classified as overweight and 22.7% as obese (Viester et al., 2017). The BMI result from different studies, however, clearly reflects that the majority of construction workers are not in their healthy range of BMI, which will have different consequences.

All the workers who were classified as overweight or obese were 25 and above in their age. Does this indicate that young workers (age < 25) are healthy thus their safety performance could be better than older workers (age > 25)? The argument in terms of heat stress could be valid, but at the same time, this needs to be kept in mind that the workers with more age become more mature and thus their behavior towards compliance of safety increase which possibly increases safe act (Sawacha and Fong, 1999; Salminen, 2004). Statistics published by the Public Authority (PASI) for Social Insurance in Oman also reveals that more than half of the disbursement cases of work injuries were related to the age group of less than 36 years, representing 76% of the total disbursement cases as shown in figure 4.10. It is worth mentioning that the PASI only registers Omani citizens in their insurance scheme (Umar, 2016). Another fact which needs to be considered in relation to this is that the foreign workers in Oman are required to be insured under private insurance schemes and Omani workers represent 8% of the total workforce in the construction industry in Oman.

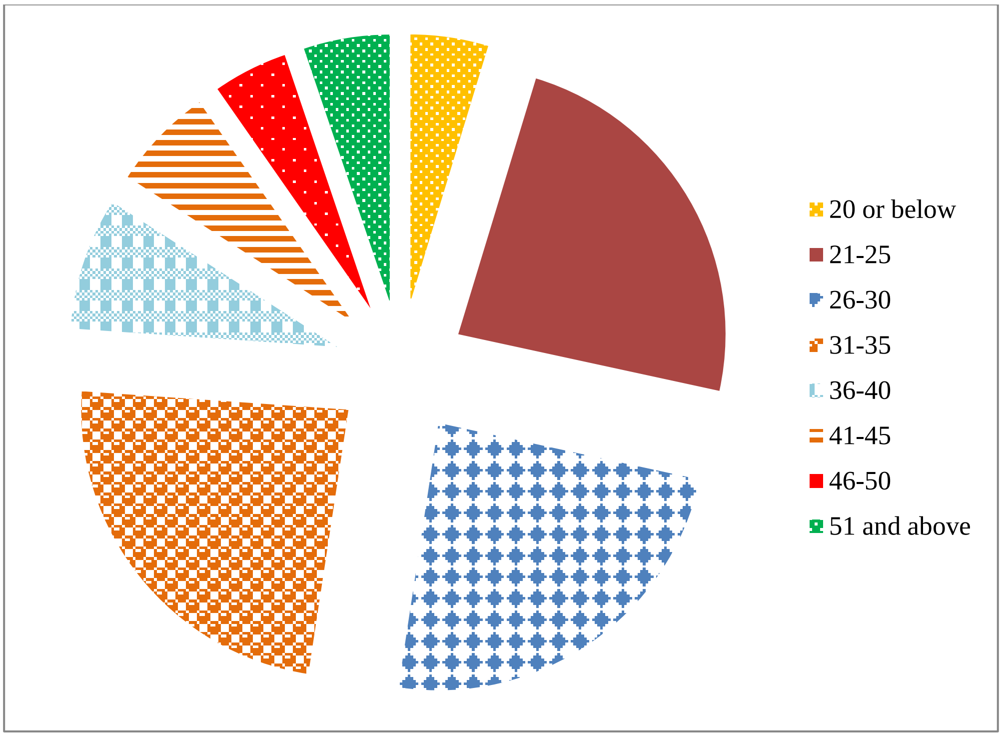


Figure 4. 10: The Distribution of Disbursement by age Group (PASI, 2014)

The next section provides some guidelines on how to protect workers from the heat stress in Oman which is derived from the literature review and the results and analysis presented in section 4.4 of this chapter.

4.7.4 Guidelines for protecting workers from heat stress:

There have been some guidelines developed by OSHA as summarized in section 2.5 of the literature review chapter which can also be adopted in Oman, this section, however, expand these guidelines based on the results obtained from the face-face interview held with some of the construction workers and on the results on the BMI and BP (sections 4.4.2 and 4.4.3 respectively). These recommendations and guidelines are summarized in table 4.21.

Table 4. 21: Guidelines for protecting workers from heat stress

Recommendation	Rationale	Guidelines
Providing appropriate supervision to monitor the environmental condition in relation to heat stress.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** Most of the interviewees reported that the climatic condition was very hot on the day when they had an accident. OSHA guidelines also recommend monitoring of the climatic conditions.	The site supervisor should have the necessary arrangement to measure the temperature and humidity level at the construction site. They should be able to know the level of risk based on the heat index and should know the preventive measures indicated in table 2.5 of section 2.5 (chapter 2). The concerned ministry also needs to ensure that such monitoring takes place at all construction sites throughout the year in general and in summer in particular.
Providing clean and cold drinking water at the site of construction.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** It is important that workers at construction site are provided with clean and cold drinking water facility. The consumption of drinking water increase while working at hot and humid conditions. Construction workers can use this water in a variety of ways to protect themselves from heat stress.	Construction organizations need to ensure that workers are provided with clean and cold water at the workplace. Government agencies responsible for occupational safety and health in the country (for instance, the Ministry of Manpower in Oman) also need to ensure that workers have such facilities at construction sites.
Allowing workers to take several short breaks in hot weather conditions.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** **c) DH (2010)** **d) CIC (2016)** **e) OSHR (2008)** Short several breaks in hot and humid climatic conditions help to reduce the body temperature of the workers. Taking breaks was the normal precautionary measure reported by the responded during the interview.	In the first instance, the workers need to be educated on the importance of short breaks during the summer period so that they cannot be affected by heat stress. Similarly, site supervisors when observer the high temperature should ask the workers for such breaks. Management should also encourage these breaks and should not relate it to productivity. Mandatory implementation of article 16 of the Occupational Safety and Health regulations, Oman and workers must not work at construction sites or in open and elevated areas from 12:30 pm to 3:30 pm during June, July, and August. The Ministry of Manpower in Oman needs to ensure this through an effective mechanism of inspections.
Providing loose and light colour uniform which can ventilate the worker body and don't absorb solar heat.	**a) Results and analyses of the semi-structured interview** **b) b) OSHA Guidelines** Construction workers need to use protective helmet, gloves, and boats as part of their routine PPE and thus can't be compromised. The only thing which could be considered is to have a loose and light colour uniform for the construction workers.	Construction organizations need to consider loose and light colour uniform for their workers. Such uniforms allow circulation of air around the human body and don't absorb the heat of the sum thus reduce the effect of the heat-stress. At some stage, the government needs to develop a code of practice related to the construction worker's uniforms.

Scheduling more physical demanding works in early morning and afternoon.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** **c) Trends of Accidents in Selected Project** The high temperature normally recorded during the day time particularly afternoon. The impact of heat-stress is also more during this time and as results more severe accidents were observed from 10:00 to 18:00. Scheduling more physical demanding works will help construction workers to be the least effect from heat-stress.	Site supervisors and managers required to ensure that all work-related activities which need more physical demand are to be scheduled in the morning or evening. The work should be scheduled in a way that it starts from heavy physical demanding activities in the morning. The physical demand of the activities should reduce as proceed to the afternoon and as the temperature increases. The activity intensity may increase as the temperature reduces. The site supervisors or managers should work closely with the scheduling manager in order to achieve this without affecting productivity.
Providing training to workers to increase awareness of heat stress and how to protect themselves from this.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** It is important that the workers have appropriate training which increases the awareness of the heat-stress and providing guidelines on how workers protect themselves from heat stress.	Construction organizations should ensure to provide training to workers so that the awareness of heat-stress could be increase. Such training should also focus on the simple steps which could help workers to protect themselves from heat stress. Such training should be part of the initial induction programs and to be repeated at least once in a year. Construction projects may vary from each other's; therefore such training should incorporate relevant aspects of the project that are closely associated with the heat-stress.
Effective implementation of compulsory day time breaks in summer.	**a) Results and analyses of the semi-structured interview** **b) Article 16 of the Occupational Safety and Health regulations, Oman** The government of Oman has made it mandatory to have a work break during summer from 12:30 pm to 3:30 pm during June, July, and August. Some of the interviewees reported that due to some reasons they are unable to take this compulsory break.	Construction organizations need to comply with the government regulation related to compulsory summer break and workers should have the full right to refuse to work during summer break time and can refuse to work overtime. The break hours can be compensated after the breaks. The concerned ministry should also implement this regulation by an effective mechanism of inspections. Such a mechanism should be able to allow random inspections of all major and minor construction projects site both in urban and rural areas.
Arranging proper rest area at the construction site for workers to relax during the break.	**a) Results and analyses of the semi-structured interview** **b) OSHA Guidelines** The implementation of summer break doesn't only refer that the workers should not work during those hours, but the workers should have access to proper arrangement areas where they can take rest during break hours. As mentioned in figure 6.1, the workers at a construction site in Oman are taking in an under-construction bridge. This	To ensure that construction workers take proper rest during break hours, they should be transported to the camp area where they have their accommodation. The construction organizations should provide transportation in this regard. The construction organization should choose their camps near to the construction areas so that the time and cost during the transportation process can be reduced. The government also needs to consider this point at the time of the review of the current

	is totally inappropriate.	regulation and due consideration may be given to this point so that the construction organizations can be made bound of this.
Maintaining a healthy diet for workers to avoid high blood pressure.	**a) Result and Analyses of BMI and blood pressure** The results and analysis of the BMI and blood pressure of the workers selected in the study and as presented in section 4.4.3 of chapter 4, reveal the majority of them are not at their healthy status. As discussed in section 7.2.3 of chapter 7, a balanced diet could play a vital role to bring such workers into their healthy conditions.	Construction workers in Oman normally live in the companies provided accommodation and the companies provide them daily food as well. Thus construction organizations should consider the healthy diet when they are planning the weekly food menu. The food should be selected in a way that could provide the required calories and can reduce BMI and blood pressure. Thus the food such as grain, vegetable, fruit, dairy product, lean meat, nuts, seed, fats, oil, and sweets should be part of the daily food to maintain the construction workers in a healthier condition.
Providing flexibility for workers to accept or reject overtime.	**a) Results and analyses of the semi-structured interview** **b) OLL (2003)** According to article 68 of Oman labour law, an employee may not be required to work for more than nine hours a day and to a maximum of 45 hours a week. Similarly, article 70 of the same law allowed a worker to work for overtime of 3 hours per day, up to a maximum of a total of 12 hours per day. The overtime should be given to a worker with his/her consent, which means that a worker can refuse to work for extra hours as overtime.	Since the majority (92%) of the construction workers in Oman are expatriates and hiring a worker from others countries cost additional amount to the construction companies, therefore these companies impose overtime on the existing workers so that they don't hire additional staff. Construction organizations in Oman however, should not impose the overtime on the workers without their consent. The existing law which regulates working hours and overtime need to be review considering the actual situation on the ground. The new regulation should allow workers to have the liberty to accepted or refuse the overtime without any consequences discussed in section 6.4.

4.7.5 Occupational Safety and Health Regulations in Oman:

Oman has displayed good progress to improve the working conditions in different industrial sectors. The occupational safety and health regulation introduced in 2008 was part of those initiatives that reflect the government's commitment to achieving better performance at the country level. A number of ILO conventions have been already rectified by Oman but still, there are few pending. Different agreements and memoranda of understanding between ILO and Oman show that Oman is committed to the implementation of the National Programme for work, which aims to build Oman's labour market and provide decent work. (TOM, 2017). The National Programme for Work is to be implemented from 2017 to 2019, and the ILO will help develop it in the Sultanate. There are also areas where the current regulations may need amendments for instance, in chapter 2 “general provision” under article 10, the OS&H programmes are only required for employers who have ten (10) or more employees. Similarly, under article 11, only the employer who employs fifty or more workers shall assign a qualified supervisor to handle the OS&H tasks. This means that if there are 9 employees in an establishment, they do not need to have occupational safety and health programme. Similarly, if there are 49 employees in a company, the company does not need to have a qualified occupational safety and health supervisor. Umar and Wamuziri (2016) noted that there were 100,000 registered construction companies in 2016. The total workforce in the construction industry in the same year was 725000 (Umar, 2016). This indicates that most of the construction companies in Oman may be very small in size considering the number of employees. Thus the current occupational safety and health regulation would not be that effective in such situations. It has been practiced in countries that exhibit good occupational safety and health performance that such regulations are revised from time to time. For instance, in the UK, the Construction, Design and Management Regulations (CDM) were first introduced in 1995, revised in 2007 and then in 2015 (CDM, 2015). Similarly, both in the USA and UK there have been separate regulations that are applicable only to the construction industry (OSHA, 3252-05N, 2005; HSE, 2018-a). While there is no comparison between the USA and UK with Oman as in the USA and UK the construction industry is quite mature, however, there are always lessons that could be learned from those countries which exhibit an improved safety performance. Thus, there is an opportunity for Oman to identify the areas in current regulation that need to be revised and if necessary, separate regulation for construction can be introduced to effectively manage occupational safety and health in the construction industry. Apart from this, many countries used to have an analysis of their OS&H regulations and their enforcement to evaluate their performance. For instance, the Labour Inspectorate in France sends around 6,000-8,000 cases to the prosecutor each year. About 76% of OS&H cases lead to fines in France, 12% to fines and imprisonment, and 2% to imprisonment (AL, 2018). Similarly, in the UK the HSE agency prosecuted 1,058 offenses in 2014-15 resulting in 905 convictions, a conviction rate of 86%. The total Fines imposed were £16.5 million (British Pound) with an average penalty of 18,198 (British Pound) per offense (HSE, 2016). The collection and analysis of such data by the relevant organization in Oman will help to evaluate the effectiveness of OS&H regulations and pave the way for improvement. The comparison of Oman regulation related to fall protection, hazard communication standard related to chemicals and scaffolding with USA, UK, AUS, and SA reflects that there is a need for improvement. The Omani regulations related to these areas are at an introductory level which may be causing confusion among the employers, employees and enforcement agencies. These regulations, particularly, covering the areas such as fall protection; hazard communication standard related to chemicals; scaffolding; respiratory protection; control of hazardous energy; ladders; powered industrial trucks; training Requirements; machinery and machine guarding; and eye and face protection are required to be benchmarked with an advanced country and need to be revised accordingly.

The next section aims to provide some discussion on the construction worker's health factors.

4.7.6 Construction Workers Health Factors:

A total of 30 construction workers of Asian ethnicity (Indian = 43.33%, Bangladeshi = 30%, Pakistani = 23.33% and Siri Lankan = 3.33%) participated in this study. These volunteers were representing the different occupational group as discussed in chapter 4. The mean values of age, BMI and sleeping hours of the respondents were 33.26 ± 8.95, 27.32 ± 3.17 and 7.21 ± 1.83 respectively. A total of 12 respondents were classified as non-smokers, 11 were classified as casual smokers and the remaining seven were classified as daily smokers. The BMI of 73.7% of the participants was more than 25; therefore they were classified as overweight or obese. Similarly, the blood pressure of 43.3% of the participants was considered to be in the rage of hypertension. Both the elevated value of the BMI and blood pressure of the participants show that the majority of them are not at their healthy condition. Such conditions are not only bad for these workers but they are also not in favor of employers and society. A healthy worker will not only be productive but could be also useful for society. Although elevated BMI and blood pressure are a global phenomenon and very common among construction workers, there are a number of factors that could change the situation. A healthy workplace, a healthy diet, and a balanced lifestyle are among these factors. It is worth mentioning here that most of the blue-collar workers which include construction workers as well as expatriates who live in Oman and their families stay back in their home countries. These workers normally go to their home countries every two years. They cannot bring their families to Oman due to certain reasons including visa restriction and financial constraints.

The body pain experience, treatment, and impact on worker's daily life are discussed in the next section.

4.7.7 Body Pain Experience of Workers:

The result of this study shows that a total of 14 (46.60%) workers reported that they suffered from pain or discomfort in the last three months. The most frequent area for pain was lower back (39.4%). A large number of participants (22%) reported that they just ignore the pain. The workers reported that pain affects their productivity and sleeping habits. Different studies have shown that musculoskeletal pain is common in construction workers worldwide. For instance, Boschman et al., (2012) concluded that in the Netherlands, two-thirds of the 750 brick workers go through musculoskeletal pain. Similarly, Deros et al., (2014) in their research related to musculoskeletal pain in the Malaysian construction industry noted that more than 60% of construction workers in Malaysia suffered from body pain. Another musculoskeletal symptom survey among 200 cement and concrete workers conducted by Goldsheyder et al., (2004) reported that 77% of the respondents experienced at least one musculoskeletal disorder in the last twelve months. A study conducted by Holmström (1992) on 1,773 construction workers, in Sweden, reported that approximately 92% of these workers experienced musculoskeletal symptoms. In this study, 46.66% of the workers reported having musculoskeletal pain in the five main common body areas, including neck, shoulder, lower back, leg, and Knee. Many researchers have found that low back pain is very common among construction workers; especially those are working in concrete and structural ironwork or working on floor and roof (Goldsheyder et al., 2004; Forde et al., 2005; Holmström and Engholm, 2003). Goldsheyder further noted that neck pain is to be more common among the painters, insulators, and crane operators (Goldsheyder et al., 2004). Kuorinka (1997) considered the main causes of work-related musculoskeletal symptoms to the repeating hand-operated tasks such as transporting, lifting, or moving heavy materials or equipment and longer duration of a static uncomfortable position. Thus, it is necessary to develop effective intervention strategies to eliminate or reduce the risk of work-related musculoskeletal symptoms. One of the best control measures is to involve and implement participatory ergonomics. Kuorinka (1997) defined participatory ergonomics as increasing the participation of those who are doing a specific work activity using a problem-solving approach for reducing the factors associated with the risk. The National Research Council has recognized the participatory ergonomics as an important and useful strategic tool to reduce the worker's musculoskeletal pain, psychosocial risk, and increase productivity (NRC, 2001). Vi, (2003) suggested the adoption of an automatic apparatus to reduce uncomfortable positions and physical exertion. In this study, the author explained the ergonomic and biomechanical advantages of using the rebar-tying machine, which can reduce more than 50% of the peak low back loading. It was concluded in the investigation conducted by Fung that construction workers normally do not understand that how much musculoskeletal injuries are serious which can have a high social impact on their life (Fung et al., 2008). Thus it is necessary to promote the awareness of musculoskeletal pain and injuries among construction workers. Strategies need to be developed to provided education and training to construction organizations on how to protect their workers from musculoskeletal pain and injuries. Construction workers also need to understand the impact of pain-related factors on their life. Adopting a healthy lifestyle that could balance work and personal life is essential in maintaining good physical health.

The next section provides a discussion on the important topic of the research related to the last objective of the project which aims to develop a safety climate assessment tool for Omani construction and can be adopted in other GCC countries.

The concluding remarks and further recommendations on the safety climate are given in the next chapter. The summary of this chapter is provided in the next section.

4.8 Summary:

The results, analyses, and discussion of the whole study except for the safety climate are presented in this chapter. The first section on the causes of accidents explained that there were a total of 623 accidents over a period of 4.5 years in the selected project which was initially divided into different categories. The chapter further explained the process adopted as outlined in chapter 3 to segregate these accidents into different classes and how the root causes of these accidents were determined. The results and analyses of these accidents show that workers were the most common cause of accidents, followed by environment, management and materials, and equipment. In section 4.3, the results and analyses of the cost of accidents in the selected GCC countries including Oman were presented. As explained in the research methodology chapter, section 3.3.2., the direct and indirect costs of accidents in Oman was established from the cost of accidents in the UK, USA, AUS, and SA. The data obtained from the Public Authority of Social Insurance in Oman was used to arrive at the costs of accidents in construction in Oman. The results show that if the average value of the costs of accidents from the USA and UK is applied in Oman, the total costs of accidents will be US$ 12,268 Million as shown in figure 4.2. Similarly, the results reveal the amount of compensation disbursed by the PASI in 2017 against these cases (~495) is equal to US$ 8.16 Million or US$ 151,135 per injury as shown in table 4.7. the results further explained that how the cost of an accident in Oman is estimated at US$ 415,620, which is 16 times more than the average costs of an accident in the USA, UK, SA, and AUS (~US$ 25,450). Overall the results and analyses of the data used in this part of the research show that the total costs of an accident in Oman result in an economic burden of US$ 205.73 Million per year on Omani economy. The results and analyses of the heat stress as presented in section 4.4 show that more severe accidents (MTI) took place around 10:00 to 18:00 (figure 4.6). The maximum numbers of different types of accidents involving injuries were from 11:00 to 17:00. The interviewees (80%) experienced different types of accidents confirmed that heat stress was one of the main causes of the accident in which they were involved. The results from the collected data show that the majority of interviewees (80%) who experienced accidents at the construction site were not in their health condition as per their body mass index (BMI). The results and analyses of Occupational Safety and Health regulations are presented in section 4.5. In this section, Omani regulations related to fall protection, hazard communication and scaffolding were compared to USA, UK, AUS and SA regulations. In each case, it was revealed that Omani regulations have a significant shortfall. The data from the International Labour Organization shows that although Oman has rectified a number of conventions, few are still pending and thus need the government attention. The study on workers' health and body pain was presented in section 4.6. As discussed in the literature review chapter, construction workers around the world are not at their required physical health which affects their performance both in productivity and safety. In order to determine the construction worker's health in Oman, three parameters that include body mass index, blood pressure and heartbeat were selected. As per the results and analyses of this study, the majority of the workers participated in this study were not in their health status. They have a deficiency in sleep and suffered a variety of body pain. The respondents selected in this study confirmed that musculoskeletal pain workers productivity (mean = 3.71) and sleeping habit (mean = 3.5) as shown in table 4.16. The worker's health is affected by a number of factors and construction organizations are required to pay appropriate attention to this area to enhance productivity and safety.

The discussion aimed to provide additional insight into the thesis considering the implication of the analyses and results presented in this chapter. Section 4.71 discussed the causes of accidents and further elaborated that why a construction organization needs to know how many accidents are arising from workers, management, environment and equipment or machinery. This can enable construction organizations to focus to target the specific area and develop strategies and explore solutions to reduce the accidents in that particular area. For instance, let say there are a huge number of accidents in construction projects which are arising from workers, so the construction organization using table 4.1 of section 4.2 of chapter 4 will be able to identify the areas which the management needs to focus on improve using different approaches. The discussion on the costs of accidents in construction in Oman presented in section 4.7.2 provides greater insight into the topic and a comparison of the costs of accidents in different countries. This indicates that the cost of an accident in construction in Oman is 16 times greater than the costs of an accident in the USA, UK, AUS, and SA. In other words, the costs of accidents in Oman put a burden of US$ 205.73 Million per year on the Omani economy. The heat-stress and its impact on construction workers in Oman are discussed in section 4.7.3 followed by recommendations and guidelines in section 4.7.4 that suggest how to protect workers from the impact of heat stress. There is a greater role of workers, site supervisors, construction organizations and the government to achieve these recommendations. A discussion on the occupational safety and health regulations is provided in section 4.7.5. The discussion shows that there is potential room available to improve the current regulations and the best way is to have separate regulations applicable to the construction industry in Oman. Construction worker's health factors and body pain are discussed in sections 4.7.6 and 4.7.7 respectively. There are certain implications of worker's health and body pain on workers' productivity and safety and thus an important area that need further improvement to enhance safety performance.

The results and analyses pertaining to the safety climate part are presented in the next chapter. The structure of the newly developed tool along with guidelines for using the tool is presented in the chapter. The chapter also presents an example of how to interpret the results collected through the new safety climate assessment tool. The chapter also aims to provide a discussion on the results and analysis related to safety climate tool.

Chapter 5: Safety Climate Assessment Tool

5.1 Introduction:

This chapter aims to present the detailed results, analysis and discussion related to research objective No. 7. This research objective as discussed in section 3.3.6 of chapter 3 is related to the development of a safety climate tool for the Oman construction industry. The safety climate study was carried out in three different parts that include the literature review, semi-structured interview and survey questionnaire. Section 5.2 of the chapter provides the results and analyses of the literature review and highlights the most common safety climate factors that include; a) Management or Organizational Commitment towards Safety, b) Safety Training, c) Employees Involvement in Safety, d) Workers Safety Behavior, e) Safety Communication, f) Safety Accountability and Justice, and g) Supervisory Leadership. The next section (section 5.3) discusses the results of the semi-structured interview held with 20 senior construction managers and engineers working in Oman. The aim of this interview was to establish the industry perception of safety climate factors and assessment. This section is further divided into four sub-sections. Section 5.4 presents the results and analyses of the data collected through a structured questionnaire (Appendix III). This section is supported by a number of figures and tables which help to understand the results and analyses easily. Section 5.5 explained the process of development of the new safety climate assessment tool (Appendix V). There is a sub-section 5.5.1 which aims to provide necessary guidelines on how to use the newly developed tool and how to interpret the results obtained from this tool. A brief discussion of the results and analysis presented in this chapter is provided in section 5.6. Finally, the last sections provide a summary of the whole chapter.

The results and analyses from the literature review are presented in the next section.

5.2 Results and Analyses of Literature Review:

The initial internet search using google scholar resulted in a huge number of results for the two terms “safety climate assessment tools” (n = 353,000) and “safety climate factors” (n = 1,470,000). Since the focus of this research was on safety climate assessment tools and on the safety climate factors used in these tools, therefore the search results from the term “safety climate assessment tools” (n = 353,000) were considered for further processing. The PRISMA flow diagram was followed to narrow down the results and to determine the final studies (n) for inclusion in this research as shown in figure 5.1. In the first step of the screening process, duplicates items (= 261,750) from the search were removed which reduced the number to 88,250. In the next screening process, google citation for the studies (n = 88,250) was used. At this stage, a total of 66,188 studies were excluded from the list considering that these studies were having a citation index less than 50. This brought the number of valid studies to 22,062 for this study. A total of 129 articles were assessed for eligibility and 21,933 were excluded with the fact that either these articles were based on the existing studies already included in the eligible articles or the articles were not accessible due to different reasons. The eligible articles (n = 129), when further reviewed, were found that the safety climate factors used in these articles were almost the same. It was, therefore, and then decided to include the top leading articles based on the number of their citations. The final articles from which the safety climates factors are derived in this research thus stand at 14 as shown in table 5.1. Briefly, the number of assessment tools found through internet search was one in each year 1980, 1991, 1997, 2000, 2004, 2005, 2006 and 2010. There were two safety climate assessment tools in 2008, three assessment tools found in 2011 and one assessment tool in 2017. The numbers of leading safety climate factors used in these assessment tools were 69. The result shows that in the first 19 years from 1980 to 1999 only three (21%) safety climate assessment tools were developed. In the next phase of 17 years from 2000 to 2017, the number of safety climate assessment tools was 11 (79%). There were two safety climate assessment tools (15%) which were not divided into factors or dimensions, while the remaining safety climate tools (85%) were divided into factors or dimensions ranging from 2 to 8 factors in each tool. This somehow reveals that it is most common among the safety science researchers to divide the safety climate assessment tools into factors or dimensions. The most common factors used in these tools were; a) management or organizational commitment towards safety, b) safety training, c) employees involvement in safety, d) workers safety behavior, e) safety communication, f) safety accountability and justice and g) supervisory leadership.

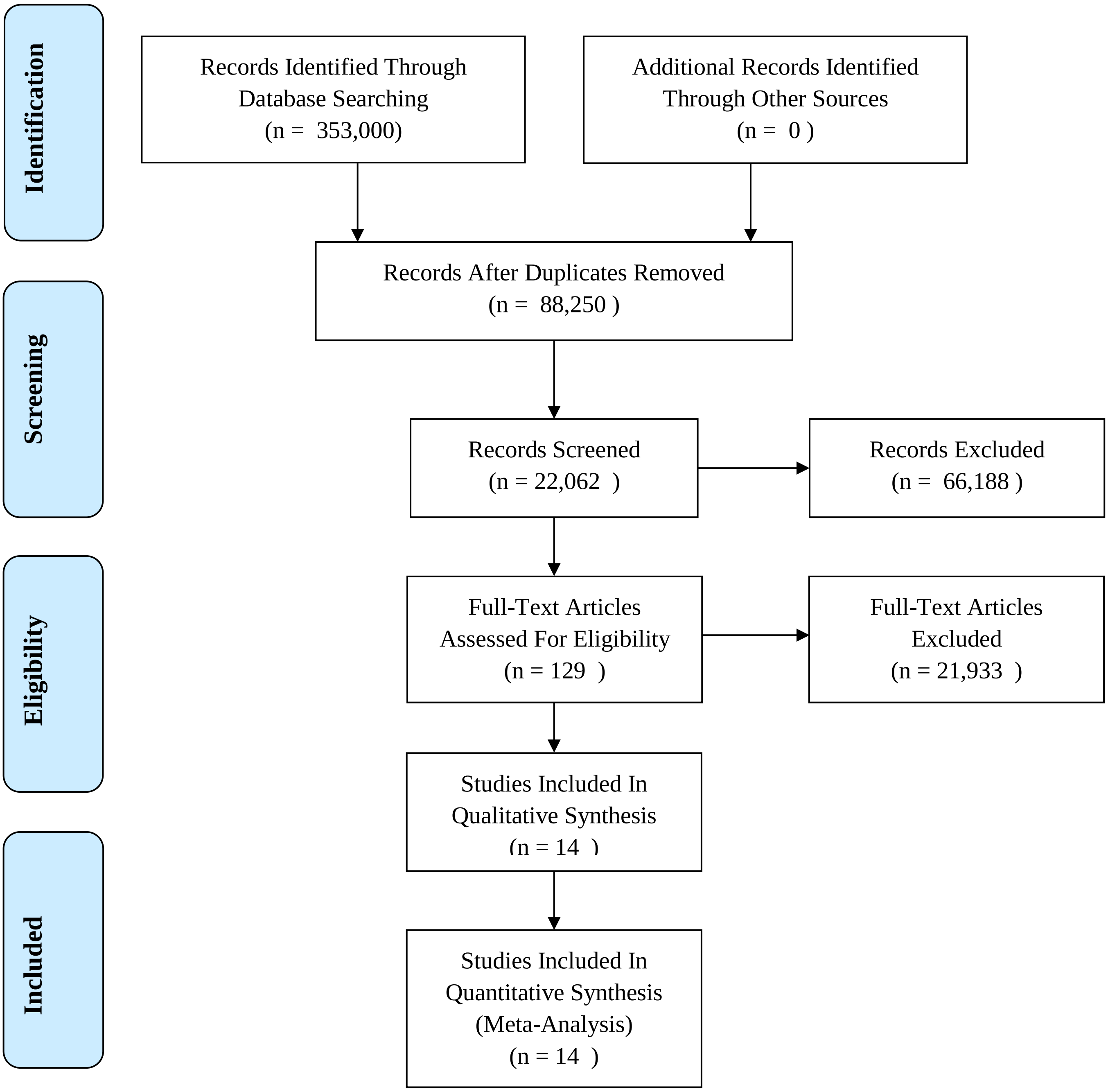


Figure 5. 1: PRISMA Flow Diagram Adopted in the Research

Table 5. 1: Details of Safety Climate Assessment Tools Factors

Safety Climate Assessment Tool	**Safety Climate Factors / Dimensions**
Zohar (1980)	(i) Management attitude toward safety; (ii) Work pace and safety; (iii) Effects of safe conduct on promotion; (iv) Effect of safe conduct on social status; (v) Perceived risks; (vi) Perceived importance of safety training; (vii) Perceived status of safety officer; (viii) Perceived status of safety committee
Dedobbeleer and Beland (1991)	(i) Management commitment; (ii)Worker involvement
HSE (UK) (1997)	(i) Organizational commitment; (ii) Health and Safety oriented behavior; (iii) Health and Safety Trust; (vi) Usability of Procedures; (v) Engagement in health and safety; (vi) Peer group attitude; (vii) Resources of health and safety (viii) Accidents and near-miss reporting
Neal et al. (2000)	(i) Management values; (ii) Communication; (iii) Training; (iv) Physical Work Environment; (v) Safety Systems; (vi) Knowledge; (vii) Motivation; (viii)Behavior
Seo et al. (2004)	(i) Management commitment to safety; (ii) Supervisor safety support; (iii) Coworker safety support; (iv) Employee participation in safety-related decision making and activities; (v) Competence level of employees with regard to safety
Zohar and Luria (2005)	(i) Active practices (monitoring, enforcing); (ii) Proactive practices (promoting learning, development); (iii) Declarative practices (declaring, informing); (iv) Active practices (Monitoring, controlling); (v) Proactive practices (Instructing, Guiding); (vi) Declarative practices (Declaring, Informing)
Parker et al. (2006)	(i) Concrete organizational aspects; (ii) Abstract organizational concepts
Pousette et al. (2008)	(i) Management safety priority; (ii) Safety management; (iii) Safety communication; (iv) Workgroup safety involvement
CISCIS (2008)	(i) Commitment and concern for Occupational Safety and Health by organization and management; (ii) Resources for safety and its effectiveness; (iii) Risk-taking behavior and perception of work risk; (iv) Perception of safety rules and procedures; (v) Personal involvement in safety and health; (vi) Safe working attitude and workmates' influence; (vii) Safety promotion and communication
Gittleman et al. (2010)	The tool is not divided into factors or dimensions
Institute of Work and Health (2011)	The tool is not divided into factors or dimensions
DeArmond et al. (2011)	(i) Safety compliance; (ii) Safety participation
Kines, et al. (2011)	(i) Management safety priority, commitment, and competence; (ii) Management safety empowerment; (iii) Management safety justice; (iv) Workers' safety commitment; (v) Workers' safety priority and risk non-acceptance; (vi) Safety communication, learning, and trust in co-workers safety competence; (vii) Trust in the efficacy of safety systems
CPWR (2017)	(i) Demonstrating management Commitment; (ii) Aligning and integrating safety as a value; (iii) Ensuring accountability at all levels; (iv) Improving supervisory leadership; (v) Empowering and involving Employees; (vi) Improving communication; (vii) Training at all levels; (viii) Encouraging owner/client involvement

The next section provides the results and analyses of the semi-structured interview held with construction professionals selected from a number of organizations in Oman.

5.3 Results and Analyses of Semi-Structured Interview:

Although the main of this semi-structured interview was to explore the perception of the safety climate factors and assessment tool in Omani industry, the information collected during this exercise was very useful to reflect the overall understanding of the safety climate approach in Oman. The results from this part are therefore divided into a number of sub-sections. The next section discusses the effectiveness of the safety climate approach for safety improvement in Oman.

5.3.1 Effectiveness of Safety Climate for Safety Improvement:

From the discussion with the interviewees, a consensus was observed on the effectiveness of the safety climate approach towards a better safety output. All interviewees agreed that an understanding of the safety climate approach and using the appropriate safety climate dimensions and factors is the main key to the effectiveness of the safety climate approach. Interviewees two and three, however, mentioned that safety is something in which responsibility cannot put only on the construction organizations. Interviewee three stressed on the safety inspections by external regulatory organizations. He stated that effective health and safety regulations and their implementation across construction organizations are very important to expect maximum safety performance. Interviewees four and five mentioned that although safety is everyone's responsibility, however, poor safety performance and increased number of accidents are not in the interest of contractors as they are the one who is affected by this. Overall all interviewees were in support of the safety climate approach, but since none of them have used this approach, their focus was on other aspects including inspections and implementation of regulations and awareness of improved safety performance among construction organizations.

The next section provides the insight of the interviewees on the safety climate factors.

5.3.2 Safety Climate Factors:

Interviewees were firstly briefed on the different safety climate factors shown in table 5.1. Their views on safety climate factors were different when asked with the question on different dimensions or factors that would need to be considered to achieve a mature safety climate and rich safety culture in construction organizations in Oman. They agreed that construction organizations in Oman need to adopt the approach of improving safety culture and safety climate to improve their safety performance. Interviewee one stated that safety training, management commitment and competence for safety and effective safety communication are the key elements of a rich safety culture and as such need to be considered as safety climate factors. Interviewees two and fifteen, views on safety climate factors were almost the same. They noted that personal commitment towards safety has a significant impact on safety outcomes; therefore personal safety commitment and knowledge of safety are some of the important elements that will influence safety culture and safety climate. Interviewee three, however, did mention the safety empowerment and stated that workers need to have the right of non-acceptance of risk. Interviewee eight highlighted the importance of accountability for safety through active monitoring and enforcing. He stated that safety compliance is important towards a safe work environment and therefore, there has to be a system that ensures that safety is not to be compromised at any level. The workers must have training on job safety or at least a safety-briefing before taking a specific work and task. Interviewee eleven stated that the main factor which can lead to an improved safe workplace is management involvement in safety. How much safety is important to management and how much they are committed towards safety is a key element. Other elements, apart from management commitment which needs to be considered are safety communication on-site, training of workers and motivation and behaviour of workers. He stressed that although personal safety comes first, workers need a level of motivation to ensure co-workers' safety as well which is very important in achieving a safer working environment. Interviewee six stated that the factors which can lead a construction organization towards an improved safety performance are related to individual and organization. Individual factors are motivation, behaviour, knowledge, and non-acceptance of risk; while organizational factors are commitment and compliance of safety, training, accountability and effective communication of safety-related things.

The interviewee's awareness of the safety climate assessment tool is presented in the next section.

5.3.3 Format of the Safety Climate Assessment Tool:

In this part of the research, an opportunity was given to the interviewees to express their view on the possible format of such an instrument if developed for construction organizations in Oman. All the interviewees agreed that they are not using any such tool for the assessment of their safety climate. Interviewees nine and seventeen did mention that they normally use the accident analyses to identify the root causes of accidents and to develop strategies to avoid such accidents in the future. Interviewee twenty mentioned that if the accident has taken place because of the worker's knowledge, then they incorporate the appropriate training to avoid such accidents in the future. All interviewees agreed that the leading safety climate factors need to be measured on a scoring scale of 1-5 (strongly agreed – strongly disagreed). Interviewee one stated that there is no need to give an option for neutral in the scoring of any leading safety climate factor and the scale can be from 1-4 (strongly agreed – strongly disagreed). Interviewee ten mentioned that such a questionnaire needs to be in multi-language to effectively serve the diverse construction industry in Oman. Interviewee thirteen mentioned the use of technology tools for using such a questionnaire instead of the paper-based approach.

The interviewee’s perception of the effectiveness of the safety climate assessment tool is discussed in the next section.

5.3.4 Effectiveness of Safety Climate Assessment Tool:

Although safety climate assessment tools are successfully used in the different industries including construction worldwide, however, the aim of this research was to know the views of construction industry professionals in Oman of their effectiveness. All interviewees agreed that a safety climate assessment tool that will allow construction organizations in Oman to assess their level of safety culture and safety climate will be helpful to improve the safety performance of construction organizations. Interviewee one mentioned that construction organizations should have sufficient knowledge of such tools before they use it properly and get full benefits from it. Interviewees three, five and fourteen stated that it is possible for all sizes of construction organizations to prepare their plans for safety improvement through the results of the safety climate assessment; however, small construction organizations can face financial and technical issues because of their capacity to implement such plans. Small construction organizations will need to have some external support to implement such plans to achieve the required level of maturity for any safety climate dimension. Factors that differentiate the safety performance of Small and Medium Enterprises (SMEs) from larger organizations have attracted the attention of many researchers which includes financial capacity as identified by the interviewees.

As discussed in chapter 3, for a study that aims to explore the perception of the safety climate factors, it is important to take the view of all the stakeholders (construction team). In order to achieve this, a structured questionnaire was used in which the view of different members of the construction team including workers, supervisors, foreman, engineers, and managers are soughed out. The results and analyses of the data collected through this questionnaire are presented in the next section.

5.4 Results and Analyses of Questionnaire Survey:

A total of 290 questionnaires were distributed to four main construction organizations that were executing major construction projects in Oman. These organizations were registered as general contractors in Oman. Data was collected from three building-related and one infrastructure-related projects being executed by these organizations. One hundred and two (102) duly filled questionnaires were returned representing a response rate of 37.17%. Four questionnaires (3.92%) out of 102 were rejected due to several reasons. The most common reason for rejecting the questionnaires was that more than 50% of the questions were not answered. The sample size was validated using equation 3.7 mentioned in chapter 3, considering the following parameters.

Z = 1.96

Standard deviation (σ) = 7.10 (calculated from age of respondents using SPSS program)

Error (d) = 1.71 (5% of the mean value of the age)

Based on these parameters, equation 3.6 gives the value of acceptable sample size (N) as 66.25 (~ 67), which is far less than the sample size used in this research (= 102). The number of responses from organization 1, 2, 3 and 4 were 28 (25.57%), 23 (23.46%), 26 (26.53%) and 21 (21.42%) respectively. All of the respondents who participated in this survey were expatriate males belong to different nationalities as shown in figure 5.2. The respondents were indifferent occupations including managers, engineers, supervisors, foremen and general workers as shown in figure 5.3. Similarly, the respondents were from different age groups and were having different educational qualifications and experience as shown in figures 5.4, 5.5 and 5.6 respectively. The ratio between skewness and its standards error for age was 0.59. Similarly, the ratio between kurtosis and its standard error for age was 1.24. Both the ratios were found to be less than $\pm$1.96, and reflect the normality of data. The correlation between age and qualification of the respondents was found to be significant at the 0.05 level (two-tailed). The internal reliability of the Likert items along with qualification, position, and country of respondents was checked by calculating Cronbach's Alpha (α) using SPSS and was found to be 0.630. The variance and Cronbach's

Alpha (α) of each factor is also calculated based on the score of each item in a particular factor. The variance of the factor "Encouraging Owner/Client Involvement" was the highest (= 0.981) which means that indicates that the data points are very spread out from the mean, and from one another (Table 5.2). This means that the results of this factor are more reliable. The mean values of each safety climate factors which respondents rated on a Likert scale of 1 to 5 are given in table 5.2. Two safety climate factors "Alignment and Integration of Safety as a Value" and "Training at All Level" got the highest mean score of 4.15 followed by "Improved Safety Leadership" and "Management Commitment" which got the mean score of 4.12 and 4.08 respectively. Overall, five safety climate factors achieved a mean score of more than 4. The mean score of two safety climate factors was near to 4 (3.80 and 3.87 respectively). One safety climate factor 'encouraging owner/client involvement' secured a mean score of 2.78. Based on the variance value of the factor 'encouraging owner/client involvement' the mean score of this factor can be considered more reliable and can be used to rank this factor. To rank the safety climate factors, the importance factor as discussed in section 3.3.6 (iii). In part X of the questionnaire (Appendix III), the respondents were also asked to rate the significance of all the eight items in relation to its importance on the safety climate. The statistical tests on this question reflect that the Cronbach's Alpha (α) was 0.71 with a mean-variance value of 0.78. Statically the value of Cronbach's Alpha (α) which is 0.71 is acceptable and further analyses based on the results of the questionnaire could be valid.

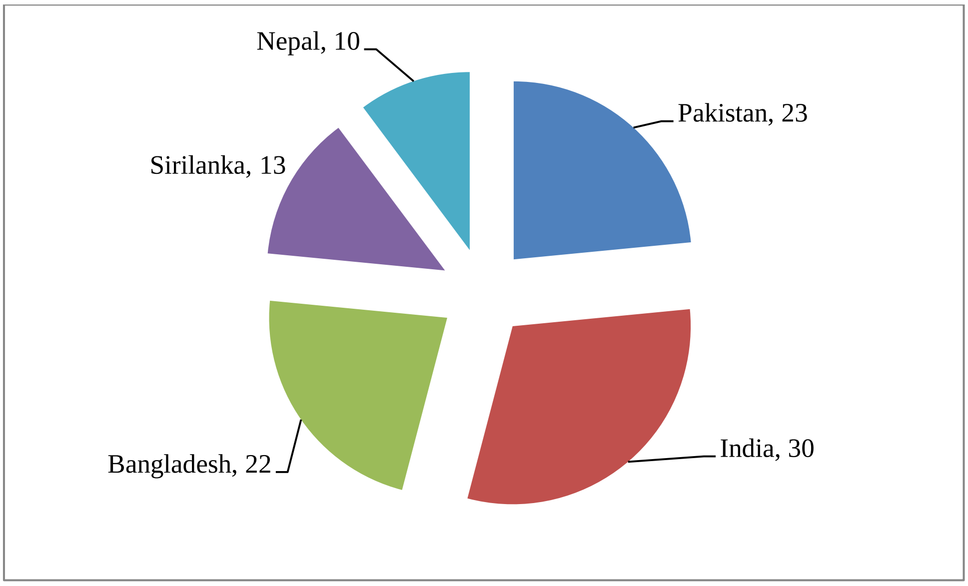


Figure 5. 2: Distribution of respondent Based on Their Nationalities

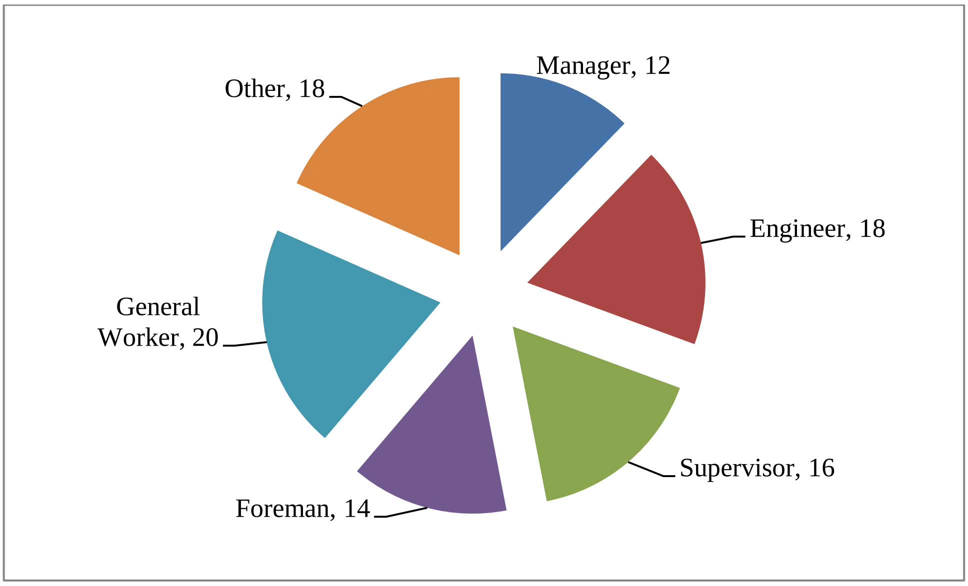


Figure 5. 3: Occupation of Respondents

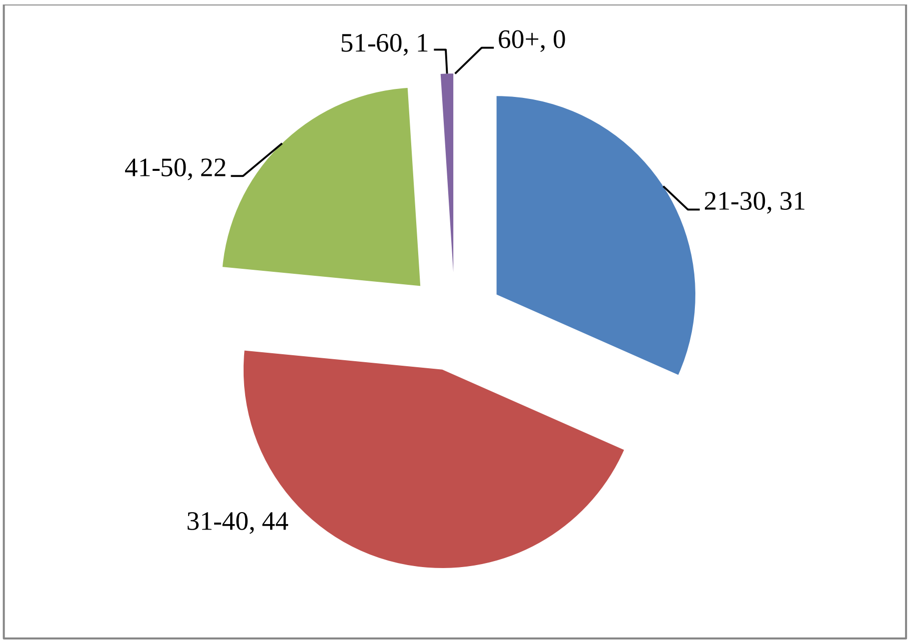


Figure 5. 4: Distribution of Respondents Based on their Age Group

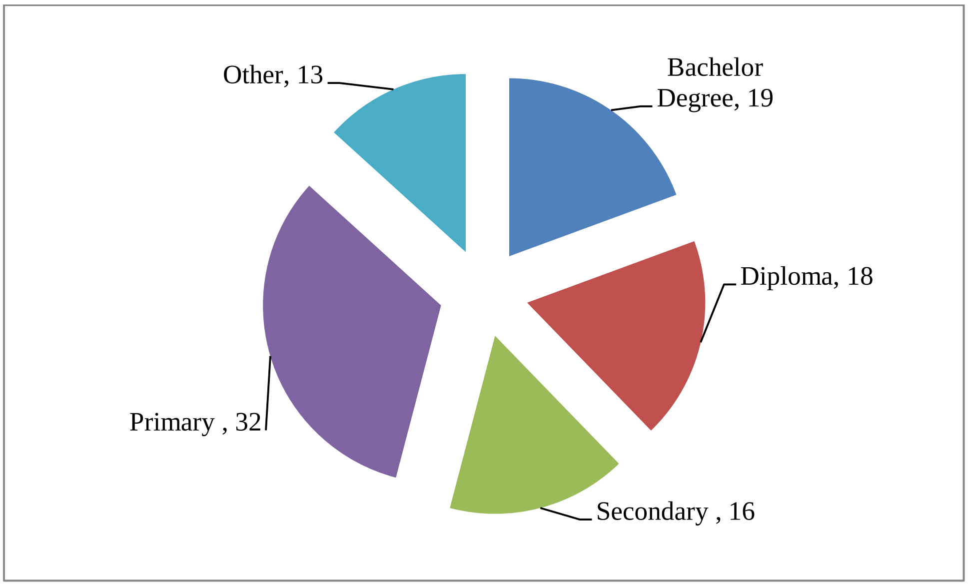


Figure 5. 5: Distribution of Respondents Based on their Qualification

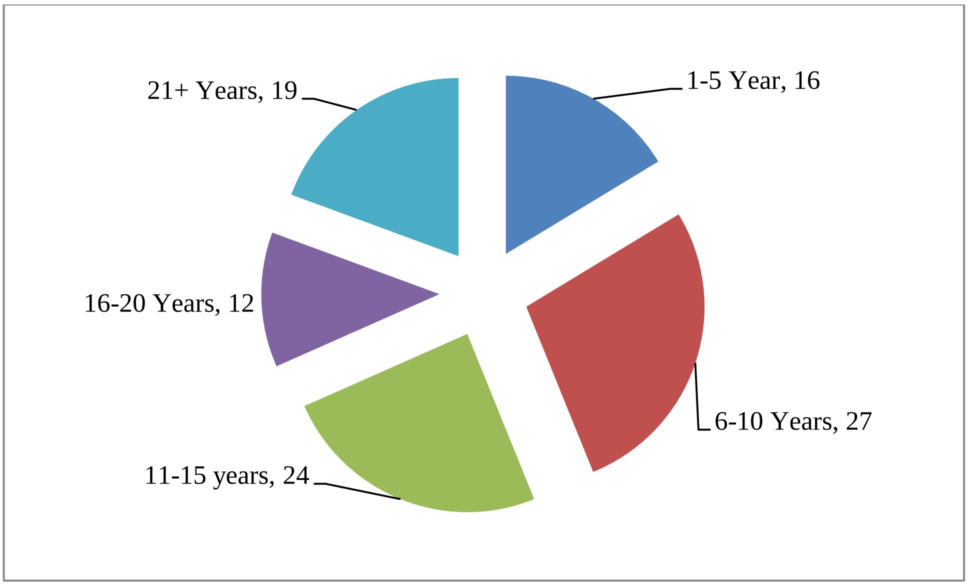


Figure 5. 6: Distribution of Respondents Based on the Experience

Table 5. 2: Mean Score of Different Safety Climate factors

Safety Climate Factors	N	Min	Max	Mean	Std. Deviation	Variance	Cronbach's alpha (reliability)	Importance Factor (Mean x Cronbach's alpha)	Rank (based on the Importance Factor)
Management Commitment (10 items)	98	1	5	4.08	0.94	0.88	0.49	2.00	4
Aligning and Integrating Safety As Value (11 items)	98	1	5	4.15	0.89	0.791	0.6	2.49	1
Ensuring Accountability at All Level (10 items)	98	1	5	4.07	0.83	0.686	0.36	1.47	6
Improving Site Safety Leadership (8 items)	98	1	5	4.12	0.8	0.645	0.51	2.10	3
Empowering and Involving Workers (7 items)	98	1	5	3.8	0.97	0.948	0.47	1.79	5
Improving Communication (9 items)	98	1	5	3.87	0.82	0.673	0.37	1.43	7
Training At All Level (7 items)	98	1	5	4.15	0.87	0.75	0.54	2.24	2
Encouraging Owner/Client Involvement (10 items)	98	1	5	2.78	0.96	0.981	0.22	0.61	8

The Spearman's Correlation Coefficient was also calculated to measure the strength and direction of the association between different variables as stated in the research methodology (chapter 3), section 3.3.6 (d). The elements considered for this analysis were age, position, qualification, experience, age group, country and all the eight safety climate factors used in the questionnaire. The results of these are given in table 5.3. The results show the correlations among some elements are significant at 0.01 and 0.05 (two-tailed). Overall, the relationships do exist in these elements, however in some cases, it is stronger and positive or negative, and in some cases, it is weaker and either positive or negative. For instance, there is a strong positive (Spearman's Correlation Coefficient = 0.933) relationship of the respondent's ages and experience which is significant at 0.01 (two-tailed). A negative relationship was however observed between respondents' positions with safety climate factors number 3 (- 0.24) and 4 (- 0.199) at a significance level of 0.01 (two-tailed). Similarly, one way ANOVA test as described in chapter 3 was also conducted to measure the significance of all factors used in the safety climate questionnaire. The factors considered for this analysis were age, age group, position, experience, qualification, and country. The p-value 0.05 or lower was considered as significant. The results show that item No. 9 and item No. 10 of the factor "aligning and integrating safety as a value" was significant (p = 0.03 and 0.017) when positions of the respondents were considered (table 5.4). Similarly, item No. 2 and item No. 3 in the "ensuring accountability" factor was significant at a p-value equal to 0.06 and 0.049 respectively when compared with the positions of the respondents. Item No. 5 in the "empowerment and involvement of the workers" factor was found to be significant with a p-value of 0.034. The p-value of item No. 6 in "improving communication" was 0.017 and thus considered as significant. The results show that there is no item significant in "owner and client involvement" as the p-value of all the items was more than 0.05. The significant items in all safety climate factors considering the above-discussed factors extracted from the results are presented in table 5.4. The non-significant items were excluded to reduce the size of the table. Overall, the table gives an overview that the items considered in relation to different safety climate factors are significant when compared with a number of respondents' parameters such as experience, education, age, and position, etc.

Since there was a relationship among the considered elements considering Spearman's Correlation Coefficient that was either stronger or weaker and positive or negative, and the significance of the items is established through the results of one way ANOVA test, the ranking of the different safety climate factors done at table 5.2 were considered reliable and was therefore adopted for the development of safety climate assessment tool.

Table 5. 3: Spearman's Coefficient of Correlation among Different Elements

			PI1 (Age)	PI3 (Position)	PI4 (Qualification)	PI5 (Experience)	PI6 (Age Group)	PI7 (Country)	Saf_Cli_Fa1	Saf_Cli_Fa2	Saf_Cli_Fa3	Saf_Cli_Fa4	Saf_Cli_Fa5	Saf_Cli_Fa6	Saf_Cli_Fa7	Saf_Cli_Fa8
Spearman's rho	PI1 (Age)	Correlation Coefficient	1.000	-.279**	-.250*	.933**	.932**	-.038	.032	-.134	-.026	-.077	-.123	-.033	.096	.127
		Sig. (2-tailed)		.005	.013	.000	.000	.708	.754	.189	.796	.452	.226	.747	.345	.213
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	PI3 (Position)	Correlation Coefficient	-.279**	1.000	.439**	-.049	-.255*	.143	-.114	.082	-.204*	.027	-.050	-.153	-.199*	-.006
		Sig. (2-tailed)	.005		.000	.629	.011	.159	.262	.423	.044	.791	.626	.133	.049	.952
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	PI4 (Qualification)	Correlation Coefficient	-.250*	.439**	1.000	-.145	-.177	.181	-.099	.049	-.178	.085	.067	.034	-.069	.056
		Sig. (2-tailed)	.013	.000		.154	.081	.074	.333	.633	.079	.405	.510	.739	.499	.581
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	PI5 (Experience)	Correlation Coefficient	.933**	-.049	-.145	1.000	.887**	-.030	.006	-.112	-.069	-.055	-.149	-.117	.056	.140
		Sig. (2-tailed)	.000	.629	.154		.000	.771	.957	.274	.500	.591	.143	.249	.584	.169
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	PI6 (Age Group)	Correlation Coefficient	.932**	-.255*	-.177	.887**	1.000	-.029	.025	-.113	-.053	-.052	-.079	-.060	.118	.189
		Sig. (2-tailed)	.000	.011	.081	.000		.776	.805	.270	.606	.613	.438	.560	.246	.063
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	PI7 (Country)	Correlation Coefficient	-.038	.143	.181	-.030	-.029	1.000	-.049	.095	-.075	.103	-.146	-.159	-.041	.016
		Sig. (2-tailed)	.708	.159	.074	.771	.776		.630	.354	.466	.313	.150	.117	.687	.877
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	Saf_Cli_Fa1	Correlation Coefficient	.032	-.114	-.099	.006	.025	-.049	1.000	.549**	.329**	.258*	.108	.003	.013	-.228*
		Sig. (2-tailed)	.754	.262	.333	.957	.805	.630		.000	.001	.010	.290	.979	.902	.024
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	Saf_Cli_Fa2	Correlation Coefficient	-.134	.082	.049	-.112	-.113	.095	.549**	1.000	.009	.197	.201*	-.166	.027	-.061
		Sig. (2-tailed)	.189	.423	.633	.274	.270	.354	.000		.928	.052	.047	.103	.794	.553
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	Saf_Cli_Fa3	Correlation Coefficient	-.026	-.204*	-.178	-.069	-.053	-.075	.329**	.009	1.000	.051	.306**	.144	.046	-.016
		Sig. (2-tailed)	.796	.044	.079	.500	.606	.466	.001	.928		.620	.002	.157	.653	.877
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
	Saf_Cli_Fa4	Correlation Coefficient	-.077	.027	.085	-.055	-.052	.103	.258*	.197	.051	1.000	-.035	-.001	-.007	.108
		Sig. (2-tailed)	.452	.791	.405	.591	.613	.313	.010	.052	.620		.734	.992	.947	.288
		N	98	98	98	98	98	98	98	98	98	98	98	98	98	98

Saf_Cli_Fa5	Correlation Coefficient	-.123	-.050	.067	-.149	-.079	-.146	.108	.201*	.306**	-.035	1.000	.359**	.260**	.359**
	Sig. (2-tailed)	.226	.626	.510	.143	.438	.150	.290	.047	.002	.734		.000	.010	.000
	N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Saf_Cli_Fa6	Correlation Coefficient	-.033	-.153	.034	-.117	-.060	-.159	.003	-.166	.144	-.001	.359**	1.000	.244*	.024
	Sig. (2-tailed)	.747	.133	.739	.249	.560	.117	.979	.103	.157	.992	.000		.016	.816
	N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Saf_Cli_Fa7	Correlation Coefficient	.096	-.199*	-.069	.056	.118	-.041	.013	.027	.046	-.007	.260**	.244*	1.000	.348**
	Sig. (2-tailed)	.345	.049	.499	.584	.246	.687	.902	.794	.653	.947	.010	.016		.000
	N	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Saf_Cli_Fa8	Correlation Coefficient	.127	-.006	.056	.140	.189	.016	-.228*	-.061	-.016	.108	.359**	.024	.348**	1.000
	Sig. (2-tailed)	.213	.952	.581	.169	.063	.877	.024	.553	.877	.288	.000	.816	.000	
	N	98	98	98	98	98	98	98	98	98	98	98	98	98	98

**. Correlation is significant at the 0.01 level (2-tailed).

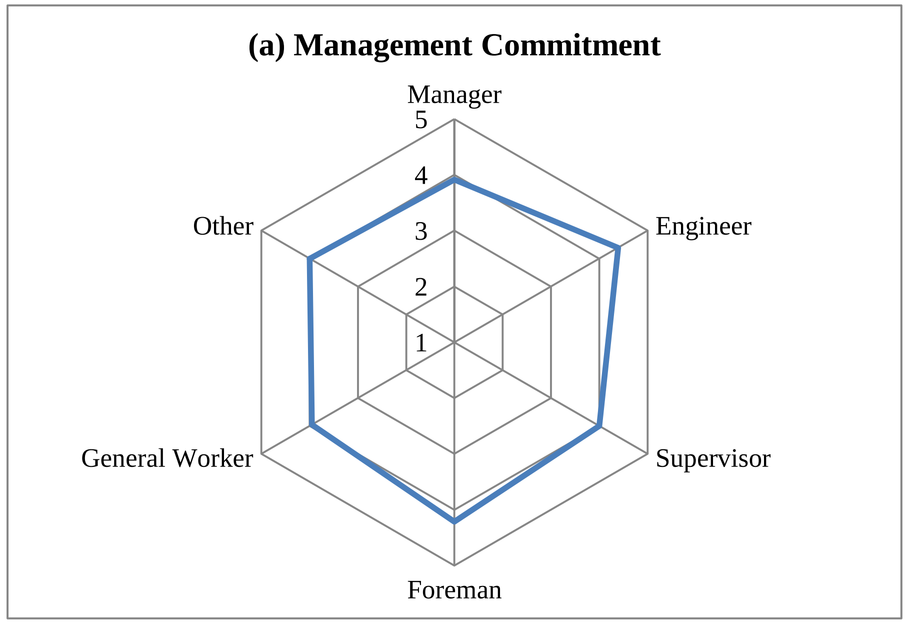
*. Correlation is significant at the 0.05 level (2-tailed).

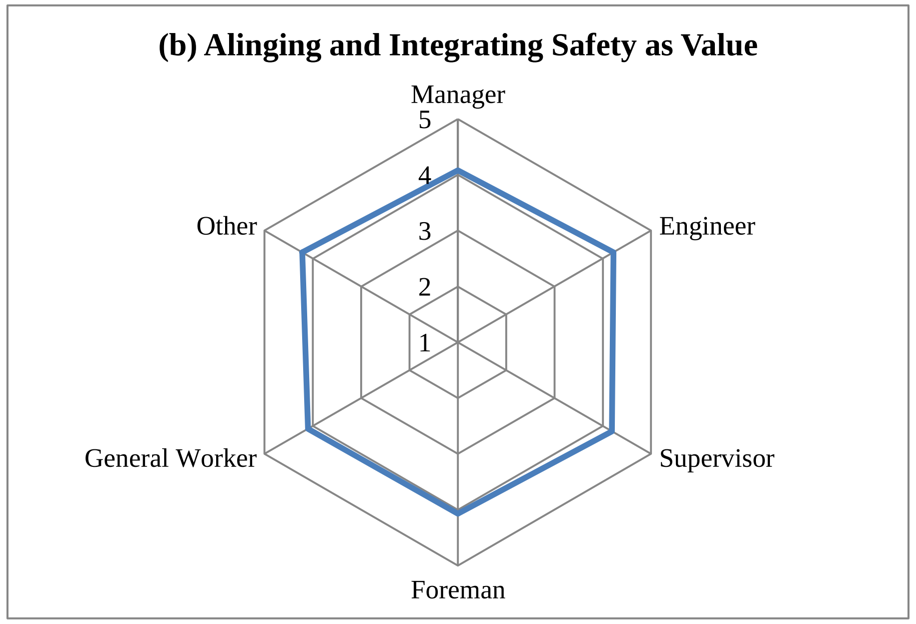
Table 5. 4: Significant of Different Safety Climate Factors' Element (One Way ANOVA)

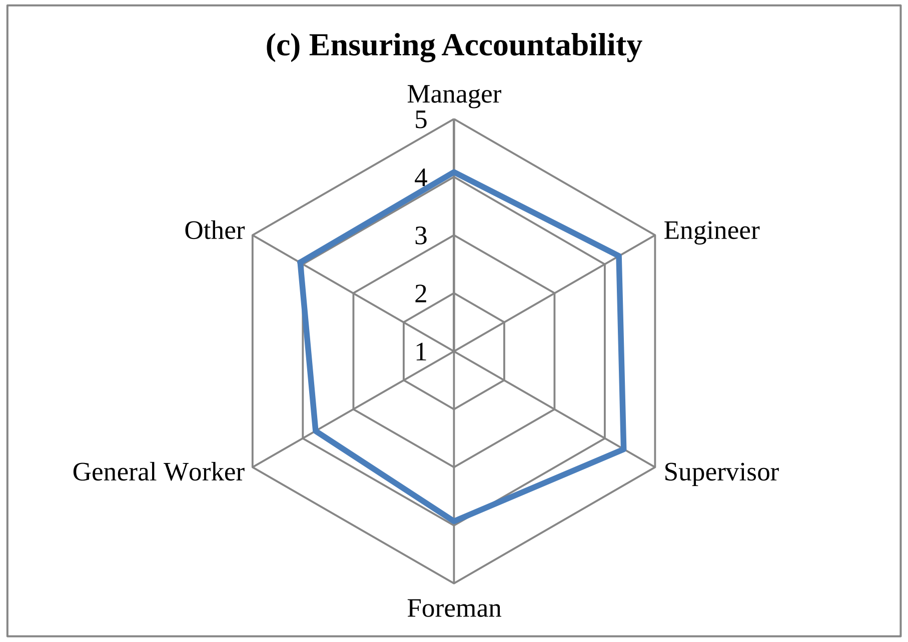
Position		Sum of Squares	df	Mean Square	F	Sig.
Align_Integrating_Safety9	Between Groups	16.886	5	3.377	2.576	.032
	Within Groups	120.594	92	1.311		
	Total	137.480	97			
Align_Integrating_Safety10	Between Groups	15.200	5	3.040	2.911	.017
	Within Groups	96.075	92	1.044		
	Total	111.276	97			
Ensuring_Account2	Between Groups	13.426	5	2.685	3.552	.006
	Within Groups	69.553	92	.756		
	Total	82.980	97			
Ensuring_Account3	Between Groups	10.494	5	2.099	2.323	.049
	Within Groups	83.138	92	.904		
	Total	93.633	97			
Emp_Invol_Workers5	Between Groups	12.387	5	2.477	2.529	.034
	Within Groups	90.113	92	.979		
	Total	102.500	97			
Improving_Communi6	Between Groups	15.823	5	3.165	2.936	.017
	Within Groups	99.156	92	1.078		
	Total	114.980	97			
Qualification		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Management_Commitment 10	Between Groups	12.938	4	3.235	2.734	.034
	Within Groups	110.041	93	1.183		
	Total	122.980	97			
Align_Integrating_Safety8	Between Groups	15.454	4	3.863	3.551	.010
	Within Groups	101.169	93	1.088		
	Total	116.622	97			
Align_Integrating_Safety10	Between Groups	18.087	4	4.522	4.513	.002
	Within Groups	93.188	93	1.002		
	Total	111.276	97			
Ensuring_Account2	Between Groups	17.583	4	4.396	6.251	.000
	Within Groups	65.397	93	.703		
	Total	82.980	97			
Emp_Invol_Workers5	Between Groups	11.469	4	2.867	2.929	.025
	Within Groups	91.031	93	.979		
	Total	102.500	97			
Improving_Communi7	Between Groups	10.226	4	2.556	2.978	.023
	Within Groups	79.826	93	.858		
	Total	90.051	97			
Age		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Management_Commitment1	Between Groups	31.061	28	1.109	1.783	.027
	Within Groups	42.939	69	.622		
	Total	74.000	97			
Align_Integrating_Safety11	Between Groups	37.298	28	1.332	2.012	.010
	Within Groups	45.692	69	.662		
	Total	82.990	97			
Improving_Communi6	Between Groups	46.157	28	1.648	1.653	.047
	Within Groups	68.823	69	.997		
	Total	114.980	97			
Owner_Client_Invol6	Between Groups	33.623	28	1.201	1.812	.024
	Within Groups	45.724	69	.663		
	Total	79.347	97			
Country		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Align_Integrating_Safety4	Between Groups	10.927	4	2.732	2.812	.030
	Within Groups	90.339	93	.971		
	Total	101.265	97			
Align_Integrating_Safety5	Between Groups	16.221	4	4.055	2.909	.026
	Within Groups	129.666	93	1.394		

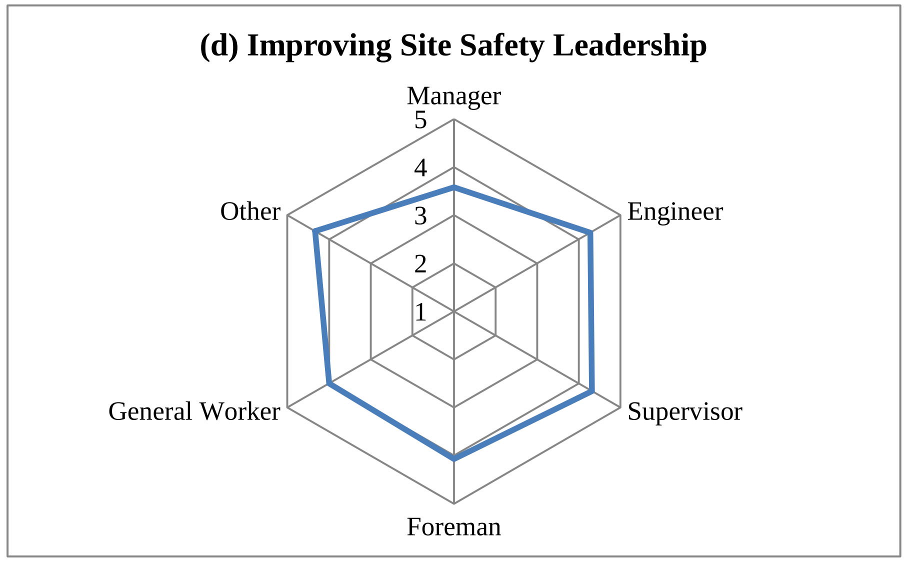
		Sum of Squares	df	Mean Square	F	Sig.
	Total	145.888	97			
Improv_Site_Safe_Leaders5	Between Groups	6.172	4	1.543	2.824	.029
	Within Groups	50.818	93	.546		
	Total	56.990	97			
Improv_Site_Safe_Leaders8	Between Groups	19.760	4	4.940	3.516	.010
	Within Groups	130.648	93	1.405		
	Total	150.408	97			
Owner_Client_Invol7	Between Groups	14.518	4	3.630	4.555	.002
	Within Groups	74.104	93	.797		
	Total	88.622	97			
Age Group		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Align_Integrating_Safety5	Between Groups	15.087	3	5.029	3.614	.016
	Within Groups	130.801	94	1.391		
	Total	145.888	97			
Ensuring_Account1	Between Groups	9.005	3	3.002	2.704	.050
	Within Groups	104.342	94	1.110		
	Total	113.347	97			
Ensuring_Account2	Between Groups	7.628	3	2.543	3.172	.028
	Within Groups	75.351	94	.802		
	Total	82.980	97			
Emp_Invol_Workers7	Between Groups	9.912	3	3.304	4.988	.003
	Within Groups	62.262	94	.662		
	Total	72.173	97			
Training_at_all_Level4	Between Groups	9.094	3	3.031	2.771	.046
	Within Groups	102.825	94	1.094		
	Total	111.918	97			
Experience		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Management_Commitment10	Between Groups	12.842	4	3.211	2.711	.035
	Within Groups	110.137	93	1.184		
	Total	122.980	97			
Align_Integrating_Safety5	Between Groups	14.174	4	3.543	2.502	.048
	Within Groups	131.714	93	1.416		
	Total	145.888	97			
Emp_Invol_Workers3	Between Groups	8.887	4	2.222	2.580	.042
	Within Groups	80.093	93	.861		
	Total	88.980	97			

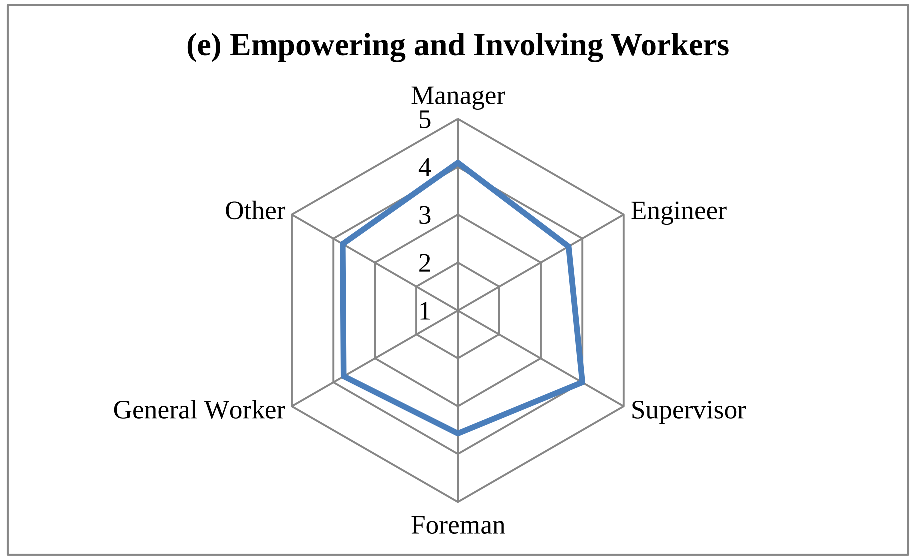
In order to rank the safety climate factors effectively, the mean score of different safety climate factors was calculated from different occupational groups as given in figure 5.7. The mean score of all the safety climate factors, except owner/ client involvement was considered significant. As mentioned in table 5.2, the mean score of “owner/client involvement” was 2.78. The Cronbach’s alpha (reliability) was 0.22. These values were based on the based on total respondents (N = 98). Thus based on the importance factor (mean score x Cronbach’s alpha), this safety climate factor was thus ranked as VII. Similarly, the same factor “owner/client involvement” mean score is 3.25 by an occupational group of “Managers”, (N = 12); by “Engineers”, (N = 18) it is 2.444; by “Supervisors” where N = 16, it is 2.625; by “Foremen”, where N = 14, it is 3.071; by “General Workers” (N = 20), it is 2.6 and by “other” where N = 18, it is 2.889. Overall, considering both the aggregate mean score (2.78) where N = 98, and the factor mean score of the safety climate factor “owner/client involvement” is lower than 3. Only the mean score by “foremen” is 3.071, however, the N = 14.

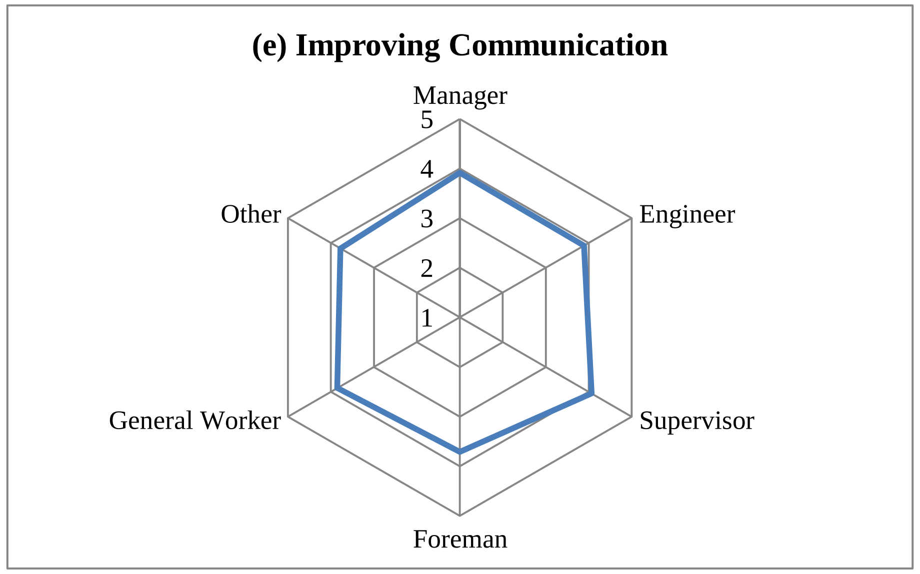

(a) Management Commitment
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other


(b) Alinging and Integrating Safety as Value
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other


(c) Ensuring Accountability
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other


(d) Improving Site Safety Leadership
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other


(e) Empowering and Involving Workers
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other


(e) Improving Communication
Manager
5
4
3
2
1
Engineer
Supervisor
Foreman
General Worker
Other

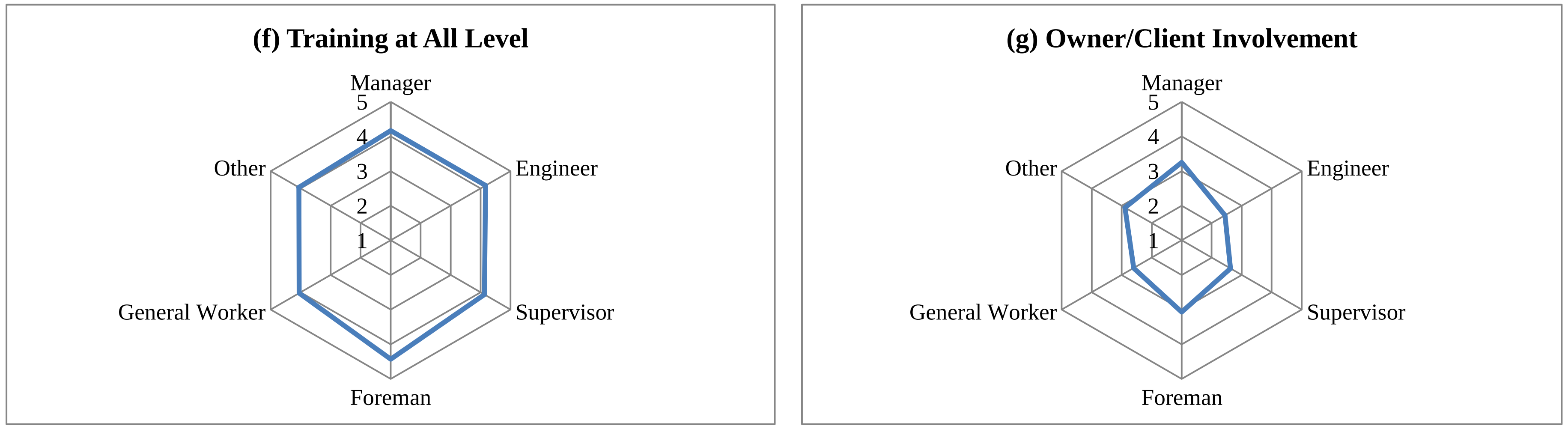


Figure 5. 7: Safety Climate Factors Scores by Different Occupational Group

The mean values of each item in different safety climate factors were calculated and these mean values were then used to rank each item in each factor. An Item which is ranked first means that the item is significant to improve the maturity level of concerned safety climate factor. The significance of the items reduces as their ranking reduced. There were a total of 10 items in “Management Commitment”. Based on the mean score of all the items, item 1, which refers to ‘defining safety expectation in policies, procedures, and guidelines, and communicated across the organization was ranked as first. Similarly, “Aligning and Integrating Safety as Value” has 11 items and item 11 has been ranked first. This item is related to ‘using safety performance metrics as leading indicators for evaluations’. There were 10 items in “Ensuring Accountability At All Level” wherein item 3 ‘adopting an owner-controlled insurance program’ was ranked first. The safety climate factor “Improving Site Safety Leadership” has a total of eight items and item 6 which is related to ‘promoting learning environment by leadership’ was on the top in raking by means score. Similarly, there have been seven items in “Empowering and Involving Workers” and item 1 ‘empowering workers through site orientations to actively participate in safety implementation’, with a mean score of 3.969 was ranked first. Item 3 ‘communicating organization materials in a consistent positive safety climate message’, in “Improving Communication” was ranked first among nine items. Similarly, there have been seven items in “Training At All Level” wherein item 7 ‘encouraging all field workers to identify training needs and develop materials’ with a mean score of 4.235 ranked as first. The last safety climate factor which is “Encouraging Owner/Client Involvement” has a total of 10 items. Item 4 ‘presence of owner representative on-site to monitor and assist with safety implementation’ with a mean score of 3.929 was ranked at the top. The whole ranking of all the items in all safety climate factors is presented in table 5.5.

Table 5. 5: Ranking of Items in Different Safety Climate Factors

(a)

Management Commitment	Mean	Rank
Item 1	4	1
Item 2	3.796	6
Item 3	3.939	2
Item 4	3.806	4
Item 5	3.796	6
Item 6	3.806	4
Item 7	3.796	6
Item 8	3.663	10
Item 9	3.786	9
Item 10	3.898	3

(b)

Aligning and Integrating Safety as Value	Mean	Rank
Item 1	3.571	7
Item 2	3.276	10
Item 3	3.122	11
Item 4	3.612	5
Item 5	3.337	9
Item 6	3.347	8
Item 7	3.918	2
Item 8	3.745	4
Item 9	3.602	6
Item 10	3.867	3
Item 11	4.01	1

(c)

Ensuring Accountability at All Level	Mean	Rank
Item 1	3.918	2
Item 2	3.898	3
Item 3	3.939	1
Item 4	3.816	4
Item 5	3.769	5
Item 6	3.765	6
Item 7	3.571	9
Item 8	3.704	7
Item 9	3.551	10
Item 10	3.67	8

(d)

Improving Site Safety Leadership	Mean	Rank
Item 1	3.673	7
Item 2	3.898	3
Item 3	3.827	6
Item 4	3.888	4
Item 5	3.99	2
Item 6	4.062	1
Item 7	3.857	5
Item 8	3.531	8

(e)

Empowering and Involving Workers	Mean	Rank
Item 1	3.969	1
Item 2	3.878	4
Item 3	3.898	3
Item 4	3.765	7
Item 5	3.786	5
Item 6	3.776	6
Item 7	3.908	2

(f)

Improving Communication	Mean	Rank
Item 1	3.929	2
Item 2	3.918	3
Item 3	4.092	1
Item 4	3.724	9
Item 5	3.816	7
Item 6	3.898	5
Item 7	3.827	6
Item 8	3.908	4
Item 9	3.735	8

(g)

Training at All Level	Mean	Rank
Item 1	3.949	2
Item 2	3.816	4
Item 3	3.908	3
Item 4	3.796	5
Item 5	3.755	6
Item 6	3.735	7
Item 7	4.235	1

(h)

Encouraging Owner/ Client Involvement	Mean	Rank
Item 1	3.704	8
Item 2	3.878	3
Item 3	3.765	5
Item 4	3.929	1
Item 5	3.673	9
Item 6	3.918	2
Item 7	3.745	7
Item 8	3.765	5
Item 9	3.653	10
Item 10	3.816	4

The result and analyses suggest that all the factors except the item "Encouraging Owner/ Client Involvement" are considered significant by the respondents. This factor is therefore excluded from the proposed safety climate assessment tool (Appendix V). The newly developed safety climate assessment tool was circulated through email to a total of 50 managers working in different construction organizations. A total of 19 responses representing a response rate of 38% were received. All the feedback received from the construction managers were positive and reflected that the proposed safety climate assessment tool could be suitable for their organizations. The structure of the newly proposed safety climate assessment tool along with a brief guideline is discussed in the next section.

5.5 Developing Safety Climate Assessment Tool:

The results and analyses of the data collected from the literature review, semi-structured interviews, and survey questionnaire, different semi climate factors could be used to assess the current maturity level of the organization or project safety climate. The existing maturity level could be further used to select the items in each safety climate factor and develop different types of plans to improve the maturity of these items. The results show that out of total eight safety climate factors, seven were considered relevant while one factor "Encouraging Owner/Client Involvement" did not attract much attention of the respondents and achieved an overall score of 2.78 on a scale of 1 to 5. Although, the mean score of this factor in more than 2.5, however, as 3 refers to neutral in the questionnaire, therefore this triggers that the respondents don't consider 'owner or client involvement' as important that to improving safety performance. Similarly, there was no significance in different the elements of safety climate factors established through one way ANOVA presented in table 5.4 also shows that almost all elements in "Encouraging Owner/Client Involvement" have no significance ($p < 0.05$). The score of remaining safety climate factors was in a significant range and therefore considered as important factors to improve safety performance. Based on the individual mean score, all safety climate factors were ranked from 1 to 8 as shown in table 5.6. Two safety climate factors (aligning and integrating safety as a value, and training at all levels) achieved the highest and similar score; therefore, both of them are ranked as first. Similarly, each safety climate is factored in different items that could be implemented by the decision-maker to enhance the maturity level of the concerned safety climate dimension. Construction organizations can select all the items in a safety climate factor or may choose some of the items depending on their capabilities and available resources. It is, however, recommended that if a construction organization could not consider all the items in a safety climate factor, the top-ranked items in ascending order. For instance, if the maturity level (mean score) of the safety climate factor “Management Commitment” is 2, and wish to achieve a maturity level of 4.5 that construction organization may consider all the items in “Management Commitment”. Since the ranking of the safety climate factors and its items presented in this research are based on the data collected from a variety of respondents from limited number construction organizations, it is; therefore, appropriate that construction organizations consider all the items in a particular factor.

Table 5. 6: Ranking of Safety Climate Factors

Safety Climate Factors	Rank
Aligning and Integrating Safety As Value	I
Training at All Level	II
Improving Site Safety Leadership	III
Management Commitment	IV
Empowering and Involving Workers	V
Ensuring Accountability at All Level	VI
Improving Communication	VII
Encouraging Owner/Client Involvement	VIII

Based on the result and analyses of the collected data, a safety climate assessment tool with a total of seven factors is proposed for construction organizations working in the GCC region (Appendix V). The safety climate factor “Encouraging Owner/Client Involvement” has been excluded from the tool due to a low mean score. Overall there are nine main items in the proposed tool. Part I which has seven sub-items is related to ‘Personal / Back Ground Information’. Part II of the tool is ‘Aligning and Integrating Safety as Value’ which has a total of 11 sub-items. Similarly, Part III of the proposed safety climate assessment tool is ‘Training at all Level’ which has a total of seven sub-items. Part IV of the tool is ‘Improving Site Safety Leadership’ which has a total of eight sub-items. Management commitment as a safety climate factor is included in part V and it has ten sub-items. Part VI of the safety climate assessment tool covers 'Empowering and Involving Workers' which is supported by seven sub-items. Ensuring Accountability at all levels is covered in Part VII of the tool and has a total of 10 sub-items. Similarly, Part VIII covers 'Improving Communication' factors which have further nine sub-items. There is also Part IX in the proposed safety climate tool which can be used if the participants have any additional comments or feedback. Items in part II to part VIII have the option to record the response of the participant on a Likert scale of 1 to 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

The next section explains some important guidelines for the construction organizations that may wish to use this safety climate assessment tool in order to improve their safety performance.

5.5.1Guidelines for Using the Newly Developed Tool:

Construction organizations that wish to use this safety climate tool for the assessment of their organization or project safety climate will have to finally calculate the mean value of each safety climate factor using the collected data. These mean values can be presented on a radar chart to effectively display the area where the organization needs to focus. Based on the mean values of each safety climate factor, the maturity level will be determined. Similarly, based on the maturity level; the type of plan to achieve the required level of maturity will be established. As a guideline, if the mean score of a safety climate factor is ≤ 4, a short term plan (6 months) is appropriate to enhance the maturity level further. Similarly, if the mean score of a safety climate factor is ≤ 3, then a medium-term plan (6 – 12 months) is appropriate. Long term plan (12 – 24 months) is appropriate if the mean score of a safety climate factor is ≤ 2.

Figure 5.8 shows the results of the safety climate assessment (example) presented on a radar chart. The respondents in this assessment were, let say the site supervisors. The figure clearly shows that the organization needs to first focus on the "Management Commitment" as it has a mean score of just 2.1. Since the mean score of this factor is less than 3, therefore the organization will need to develop a medium-term plan (6 – 12 months) to improve the maturity of this factor. Similarly, the factor "Aligning and Integrating Safety as Value" has a mean score of 4.2. If the construction organization wishes to improve the maturity level of this factor further, a short term plan (6 months) will be implemented. After successfully implementing all the plans, the construction organization needs to assess the maturity level of all the factors. In other words, this has to be a continuous process.

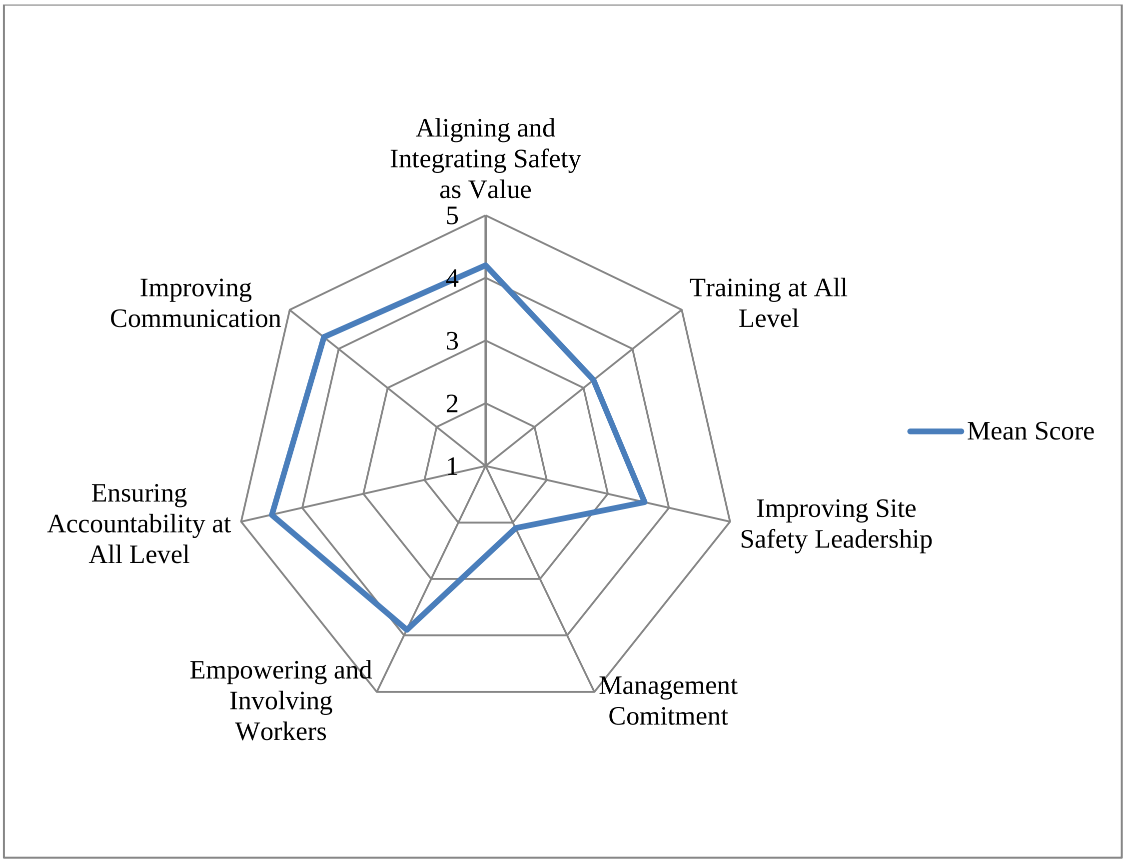


Figure 5. 8: Results of Safety Climate Assessment (Example)

It is also important the construction organizations in the GCC region ensure that their employees feel free to participate in such assessments. Construction organizations in the region will have to develop trust among the workers by ensuring that their responses should be considered anonymous and it will have no implication on their job security. The main drawback of the newly developed safety climate assessment tool is the language. It is currently written in English, however, most of the blue-collar construction workers in the GCC region are currently unable to read and write in English, it is recommended that the data from such workers may be collected through an interview and the responses may be recorded on the tool. This idea, however, has some disadvantages. For instance, the worker may feel under-pressure and would not be able to disagree with the items as someone is monitoring his/her response. In other words, the data collection is not anonymous. The other disadvantage of this method is that the workers in the GCC region are from different nationalities and it would be difficult for construction organizations to find the appropriate person to conduct the interview and record the response of the workers on the tool. Another solution to this situation is to develop a mobile application that could translate the tool into the mother language of the respondents. The application should have the ability to translate the tool into different local languages. Such an application may also be connected to the main server of the organization and should have the ability to process the responses automatically.

The guidelines are briefly summarized in the following points.

1. It is important that the organization collects the data from their employees with their consent and ensure that the employees have no pressure to complete the questionnaire.

2. The person administering this questionnaire should have basic knowledge of how to distribute a questionnaire among the worker groups. He/she also needs to have basic knowledge of MS Excel to record and analyses the collected data.

3. The workers should be given appropriate information regarding the purpose of the survey.

4. The tool is developed in the English language, so if the respondent (s) are unable to read and write the questionnaire and would like to participate in the survey, he/ she must be provided with proper assistance so that his/her response is recorded. The person assisting in this must not influence the response of the participant.

5. The data collected must be treated as anonymous.

6. The data should be entered into an excel sheet. Appropriate templates for data entry can be prepared in MS excel or can be obtained from the author by sending a request to tariqumar1984@gamil.com.

7. If in any questionnaire more than 50% of the questions are not answered, then it can be ignored and the data is not required to be entered.

8. After the data collection, the mean score of each factor is to be calculated based on the score of each element in that factor.

9. The last section of the tool which is provided for the comments of the respondents needs to be checked properly and this needs to be analyzed separately.

10. If the number of respondents in a group is thirty or more then it is better to process such data separately as it will be more helpful to develop separate plans for the improvement.

11. The mean score of the data can be presented on an appropriate chart (radar chart) as mentioned in figure 5.8. This would be helpful for the top management to interpret the results easily.

12. It is ideal to consider the factor with the lowest mean score on the first priority and develop a plan for improvement starting from that factor.

13. It is up to the organization to develop appropriate plans that can be helpful to improve the maturity (mean score) of a particular item. These plans could be short-terms, medium-terms, and long-term depending on the factors itself.

14. The reassessment of the safety climate should only take place after the developed plan has been successfully implemented.

15. If the reassessment reflects no improvement then it means the plan which was implemented to bring improvement in the safety climate factors was not effective.

16. If the organization wishes to share its data with the author, it can be sent to tariqumar1984@gmail..com. The author will be able to provide an insight into the results and the area where the organization needs to focus.

17. A training session (two hours) can also be organized for the organization to help them better understand the process of data collection, analyses and interpretation of the results.

18. Organizations using this tool are encouraged to share their data with the author so that a region database could be established. The entire data share with the author will be treated as confidential and will be only used for research purposes.

The next section provides a comprehensive summary of the chapter.

5.6 Discussion: Safety Climate:

As discussed in section 2.8 of chapter 2 that organizational culture and organizational climate are considered important elements to provide direction to organizations to improve their performance in a specific area. Safety climate is regarded as a sub-set of the organizational climate which provides a predominant path to improve the safety performance of organizations. There have been a number tool developed in the part particularly after 1980 when this concept attracted the attention of both safety researchers and practitioners. These tools and the factors used in these tools have been identified through a systematic literature review described in section 3.3.6 (i) of chapter 3. The results of this review are presented in table 5.1 of section 5.2 of this chapter. This literature review results in a total of 14 tools with a number of factors. The table shows that there was however no tool developed for the GCC construction industry while only a few were actually developed for the construction industry. This research, therefore, aimed to develop a safety climate assessment tool for the Oman construction industry that could be used in other GCC countries. A mixed-method approach that includes both quantitative and qualitative methods was adopted to achieve this. Finally, a safety climate assessment tool that has a total of nine parts including seven safety climate factors derived from the results and analysis of semi-structured interviews and survey questionnaires presented in sections 5.3 and 5.4 of this chapter. The tool is developed considering the top-ranked factors and the factors with low mean score and significance were excluded (Table 5.2, 5.3 and 5.4 of chapter 5). The low mean score or the factors with no significance means that the factor is less relevant to the respondents selected for this study. Since the tool was developed from the data collected in Oman and validated by construction professionals working in Oman, therefore it is more appropriate to measure the existing level maturity of the dimension adopted in the tool and to identify the areas for improvement. The guidelines related to the use of the tool and how to interpret the results obtained through this tool are provided in section 5.5.1 of chapter 5. As discussed in section 2.8 of the literature review chapter, safety climate assessment tools are considered the best instrument to measure the maturity level of different dimensions and allow construction organizations to focus on those dimensions which are lower level, longitudinal studies are still required to be conducted to show how much improvement such tool can bring to the organizational or project safety performance. It is also important the construction organizations share their plans which bring improvement in the maturity level of their assess safety factors. It is also important to note that a plan which brings the required improvement in the maturity level of one organization or project may not bring the same level of improvement in the other organization or project. This may happen due to different reasons in which the size of the organization and nature of the project or project team could be important. Overall, at the moment a safety climate assessment tool is available to the construction industry in Oman, which opens the doors for further associated and important factors that need to be considered. Although, a good number of construction professionals considered this developed safety climate assessment tool as a useful tool for their organization/ project safety climate assessment, at first instance the construction organizations in Oman need to come forward and to use this tool. This will help to see the effectiveness of the tool further and will be helpful to review and revised the tool in the future.

5.7 Summary:

In this chapter, the study around the development of a safety climate assessment tool for Oman and the GCC region was reported. As discussed in section 2.8 of the literature review chapter that safety culture and safety climate are the predominant approaches that organizations around the world are using to improve their performance in different aspects including safety, this study in relation to the GCC region in terms of safety performance in quite important. The statistics presented in chapters 2 and 4 related to safety in construction and its associated expenditure in Oman and other GCC countries are quite alarming and it is important to reduce the number of accidents and expenditures arising from such accidents. There are a number of factors that highly influence the safety climate in construction which have not been investigated before in Oman or other GCC countries. Thus this investigation was one of the main objectives of this research. The research approach adopted to achieve this objective was discussed in detail in chapter 3. The results and analysis of the data collected from the literature review (14 items), semi-structured interview (20 respondents) and questionnaire (102 respondents) reveals that aligning and integrating safety as value, training at all level, improving site safety leadership, management commitment, empowering and involving workers, ensuring accountability at all level and improving communication are the key factors which highly influenced the safety climate in Oman. The developed safety climate assessment tool considering these items was validated by sending it to the construction industry professional in Oman. The chapter also provides some basic guidelines on how to successfully use this safety climate assessment tool and how to interpret the data collected through this tool. It is important that construction workers feel free when they participate in such assessments. As the majority of construction workers in Oman and other GCC countries (table 2.12 of chapter 2) are illiterate and the newly developed questionnaire is in English, construction organizations in the region need to use suitable approaches to ensure these workers participate in safety climate assessment. Some of the possible recommendations that could be used in such situations are provided in section 5.5.1 of this chapter. The current factors used in the safety climate assessment tools need to be reviewed on a periodic cycle of five years to ensure that the considered factors still highly influencing the safety climate. The current factors or the items in different factors may be amended provided that review establishes that it needs changes or revision.

The next chapter is the conclusion and recommendation chapter. Apart from the conclusion and recommendation, the chapter also provides an insight into the knowledge contribution and limitation of the research project.

Chapter 6: Conclusion and Recommendations

6.1 Introduction:

In this chapter of the thesis, the conclusion and recommendation of the study are discussed in detail. Since the study considered a number of the parameters associated with the construction industry, therefore the chapter is divided into different parts considering these parameters. The parameters selected in this research highly influence safety performance in construction. Section 6.2 of the chapter provides a conclusion on different areas of the research. This section has a number of sub-sections. Section 6.2.1 provides concluding remarks on the causes of accidents. Since the causes of accidents in this part were derived from a highway project, it is recommended in this section that further research needs to be conducted on the causes of accidents in building projects. Section 6.2.2 concluded the cost of accidents in GCC construction. Normally construction organizations don't pay enough attention to safety; however, if there is an accident, these organizations bear huge costs. Thus the findings of this part could be helpful to motivate the construction organizations on investing in safety. One of the drawbacks of this research was the availability of raw data, therefore it is recommended in this section that construction organizations and medical insurance companies need to support such research by proving the relevant data. Heat stress is concluded in section 6.2.3 of the chapter. The guidelines to protect workers are briefly concluded in this section and it is recommended that further research needs to be conducted in this area to monitor the improvement in safety by using these guidelines. Section 6.2.4 concludes the occupational safety and health regulations as an important factor that contributes to safety improvement. Key areas of occupational safety and health regulation are identified which need regulation and guidelines. Workers' health factors and body pain are considered in section 6.2.5 which concludes that the construction workers in the region are not healthy which could affect their productively as well as safety performance. Different areas are recommended in this section to be considered to improve worker's health indicators. Finally, in section 6.2.6, the safety climate and the newly developed tool are discussed. Further research in the area of safety climate is also recommended in this section. Different recommendations arising from the research project are provided in the recommendation section (section 6.3) and its different sub-sections. Similarly, knowledge contribution, research limitation, and further research are stated in sections 6.4, 6.5 and 6.6.

The next section of this chapter is the conclusion section supported by a number of sub-sections.

6.2 Conclusion:

6.2.1 Causes of Accidents:

The approach adopted in this research for finding the causes of accidents divides the causes into the main four categories “Equipment / Materials”, “Worker”, “Environment” and “Management”. There have been a number of tracing models used in the construction industry, but these models are apparently complex in nature and the industry is reluctant to adopt them. It was, therefore, necessary to develop a simple tracing model that is not only easy to use but also the construction industry is willing to adopt. The data of accidents (= 623) was collected from two construction organizations that were executing a highway construction project in Oman. Both of the organizations were, however, registered as a general contractor in Oman. The accidents were initially divided into five different categories that include “Alternate Work Injury (AWI)”, “First Aid Injury (FAI)”, “Loss Time Injury (LTI)”, “Medical Treatment Injury (MTI)” and “Property / Equipment Damage”. The accidents causing tracing model developed and validated was applied to these accidents. The results show that the causes of 42% of the accidents were directly linked to the workers. Of course, the other causes include Equipment / Materials (=14%), Environment (13%) and Management (=31%). When the decision-makers in the construction organizations will know what causes the accidents in their projects, they will be able to make effective strategies to encounter the causes and thus the number of accidents could be reduced. The results obtained from causes of accidents in a construction organization may also be shared with all stakeholders including workers, client, and consultant so that they could have a better understanding of what cause such accidents in their project. This will bring awareness among the stakeholders which could result in a more mature action. For instance, when the workers will know how they could be the cause of an accident, their actions in the workplace will be safer. This will lead the workers to learn how such causes can be avoided at their part. Similarly, the environmental condition also contributes to a significant number of accidents. In most cases the work at construction sites going on even if the environmental condition is not appropriate. The main reason for this is that the contractors normally want to complete their work faster and this is because sometimes contractors have pressure from the client or the consultant. When all the stakeholders such as contractors, clients, consultants, and workers will consider the environment as a possible cause of accidents, the work in not be forced to be carried out in a bad environmental condition. Similarly, the client and consultant will consider such reasons as a valid excuse if causes any delay to the work.

Since the causes of accidents presented in this research are based on the data from a highway project, and since there is a difference between a highway project and a building project, therefore, such research is recommended to be carried out for building projects as well. The causes tracing model in this research was applied on the accidents of a project, therefore it is recommended that this model may be applied on a number of such projects to enhance the overall understanding on the causes of accidents and to evaluate that this tracing model can be adopted effectively or it needs some modifications. A few recommendations related to the causes of accidents are presented in section 6.3.1 of this chapter.

The next section aims to provide a conclusion on the cost of accidents in construction.

6.2.2 Cost of Accidents in Construction:

The construction industry in the GCC region is heavily population from overseas workers (= 90%). Under the current systems and procedures adopted in the region, such workers are medically insured through private medical insurance companies. The cost of accidents is a complex phenomenon; however, it can be classified into two categories i.e. direct costs and indirect costs. The direct costs that include the medical treatment and compensation costs while indirect costs include reduced productivity for both the returned worker(s) and the crew or workforce, clean-up costs, replacement costs, costs resulting from delays, supervision costs, costs related to rescheduling, transportation, and wages paid while the injured is idle. Accidents in construction happened, but not on a regular basis. Construction organizations remain reluctant to invest money on matters that don’t arise on a regular basis. The fact is that when such accidents happened, it results in a huge cost. The aim of this part of the research was to estimate the cost of accidents in construction considering the GCC region that will motivate construction organizations to spend on safety-related issues without hesitating. The Cost of Accidents in GCC construction is estimated in this research is based on a number of assumptions and co-relations as there is a lack of availability of the raw data required for this purpose. Four medical insurance companies in Oman were contacted for cooperation in this research, however, no company responded. One major medical insurance company was also visited personally, however, this company refused to provide any insuree data. Five major construction companies in Oman were also contacted for the same purpose; however, no company comes forward to provide any data related to the costs of accidents and injuries. The cost of accidents, thus estimated in this research was based on the available data in three main countries within GCC including Qatar, Oman, and Saudi Arabia. The cost of a workplace accident in construction was based on a number of parameters. These parameters include the values of the current projects in the three main countries including Qatar, Oman, and Saudi Arabia; and the amount disbursed by the government organizations against injuries, disabilities, and deaths. The cost of accidents in these countries was compared with the average cost of accidents in the USA, UK, SA, and AUS were used. The total costs of an accident in Oman are estimated at US$ 415,620 which is 16 times more than the average costs of an accident in the USA, UK, SA, and AUS (~US$ 25,450). This costs further results in an economic burden of US$ 205.73 Million/year on the Omani economy. In Saudi Arabia, the costs of an accident are estimated at US$ 91,940, while the economic burden on the Saudi economy is estimated at US$ 261.11 Million/year. The total costs of an accident in Qatar are equal to US$ 205,526 which is almost nine times more than the average costs of an accident in the USA, UK, AUS, and SA (~US$ 25,450). In these estimates, the direct costs are calculated from the indirect costs of accidents due to the lack of available data. Construction organizations and medical insurance companies are required to facilitate such research so that a more reliable estimate of the costs of an accident in GCC's construction could be produced.

The next section provides a conclusion on the heat-stress study.

6.2.3 Heat Stress:

It is an established fact that extreme heat stress has a deep impact on physiological reactions, which results in occupational injuries and deaths. GCC region is well known for its hot and humid environment which heavily affects the worker's performance. This was established using a three stages methodology. In stage I, the trend of 623 accidents collected from a construction organization was analyzed. In stage II, 20 construction workers involved in these accidents were interviewed and finally, in stage II the field measurements of BMI and BP of the same construction workers who were interviewed in stage II were carried out to see that these workers were physically fit. The results of this research show that the number of accidents has increased gradually from 10:00 to 17:00. A decline in the number of accidents was observed after 17:00. This has a direct relationship with the temperature. The temperature in Oman from 10:00 to 17:00 is normally high compared to the rest of the day. A slightly high number of accidents were also observed in the early morning (3:00 – 6:00) and nighttime (20:00 – 24:00). This may have no relationship with heat stress but several other reasons for example drowsiness of workers and low light arrangement at the workplace. A large number of accidents (= 32) were also observed on Saturday at 16:00 – 17:00, which have a relationship with the heat stress, but also Saturday is the first day of the week where the work started for all private sectors in Oman and other GCC countries. The results show that more severe accidents (MTI) took place around 10:00 to 18:00. All the interviewees agree that heat stress was one of the causes of accidents in which they were involved. Although there is a regulation in force in Oman that states that workers must not work at construction sites or in open and elevated areas from 12:30 pm to 3:30 pm during June, July, and August, however, the interview held with the workers reflect that this regulation is not followed in a true letter and spirit. The concerned organization in Oman and other GCC countries need to ensure that such regulations are strictly followed by the construction organizations in the region. It is not only to stop the work at the construction site during this period, but construction organizations need to facilitate the workers by providing proper arrangements so that they can take rest during this time. The results further show that most of these workers (= 50%) who were interviewed were under sleep (~5 hours). There have been studies that conclude that a worker with a good and uninterrupted sleep could be more productive and safer. The total working hours per week and enforced over time are among the areas which negatively affect the worker's safety performance. The data on BMI and BP show that the BMI of 12 o participants (60%) was in the range of overweight while four participants (20%) were obese. Based on the BP results of the participants, 40% (8 participants) were classified as hypertension. The effect of heat stress on workers with high BMI and BP values will be more as compared to healthy workers. Health workers will not only be more productive but also safety which is in the greater interest of the construction organizations and society. A balanced diet could play a vital role to bring such workers in their healthy conditions. This research has resulted in a number of guidelines that could be useful to protect workers from heat stress in the GCC region. These guidelines include monitoring the environmental condition, providing clean and cold drinking water, allowing several short breaks, providing loose and light color uniform, effective scheduling, providing training, implementation of breaks in summer, healthy diet, facilitating breaks and flexible over time. Further research needs to be conducted to observe the improvement in safety performance after implementing these guidelines in construction organizations.

The conclusion on the occupational safety and health regulations is provided in the next section.

6.2.4 Occupational Safety and Health Regulations:

The presence and effective enforcement of robust occupational safety and health regulation are important to enhance safety performance and reduce accidents. As of other aspects of construction safety in the GCC region, occupational safety and health regulations are also comparable in these countries. The aims of this part of the research were to review these regulations, compared them with the regulations in some advanced countries such as the USA, UK, SA, and AUS and provide suggestions for improvement. A qualitative research approach was adopted and Omani regulations were considered to achieve the aims of this research. Oman's regulations, standards and guidelines around (i) fall protection, (ii) hazard communication standard related to chemicals and (iii) scaffolding was made with USA, UK, AUS, and SA. There were a total of 25 articles in fall protection regulations enforce in the USA which addresses a variety of issues related to fall protection. Similarly, there is a separate law for fall protection in the UK which has a total of 19 main articles, supported by a number of sub-articles and a total of eight schedules. In Australia, there is a separate code of practice for working at height. This code of practice consists of 10 chapters and two appendices which deal with most of the issue related to fall protection. In South Africa, the latest 'Work at Height' regulations came into force in 2013 which has a total of six schedules, supported by a number of main and sub-articles. Fall from a height was established as one of the main causes of accidents in different sectors in Oman however there are no specific regulations that cover this cause of accidents in detail. The only regulation which is applicable to the fall from height is the Regulation of Occupational Safety and Health, issued by the Ministry of Manpower in 2008. Overall, the review of the whole regulation applicable in Oman shows that although the terms fall, appear several times in the regulation but don't cover the full spectrum of the fall protection in detail. The regulation should be detailed in all aspects and should provide complete guidelines when dealing with any hazard related to fall protection. The current standards related to hazard communication (chemicals) applicable in the USA came into force in March 2012. The standards have a total of 10 main articles which are further supported by many sub-articles. There are comprehensive guidelines on the Classification of Hazardous Chemicals which falls under the Work Health and Safety Act and Regulations in Australia consist of 34 pages and 12 sections supported by 10 tables and seven appendices. The European Regulation on classification, labeling, and packaging of substances and mixtures are applicable in European Union Member States, including the UK which consists of 1389 pages, 62 articles which are further supported by several sub-articles, tables, and appendices. Similarly, there are several Acts and regulations in South Africa which aim to control the hazards of industrial chemicals as discussed in section 4.5.2. In Omani regulations, chemical hazards are also covered in a separate section (Article 37) which has further 12 sub-articles that describe the precautions that need to be considered to protect workers against the risks of exposure to the chemicals. Overall, the provision of chemical hazards in Omani regulations is not of the standards as adopted in the USA, UK, AUS, and SA. The term “scaffolding” was not found in the current regulations enforced in Oman. The term “ladder” was, however, used at five different instances in the regulations which obviously cannot substitute the scaffolding. In the United States, there are separate guidelines for scaffolding used in construction which include general requirements for scaffolds; specific Scaffold; aerial lift requirements; and training requirements. Health and Safety Executive (HSE) in the UK is responsible for providing the guidelines and checklist for the scaffold which are based on the National Access and Scaffolding Confederation (NASC) Technical Guidance (TG20) for tube and fitting scaffolds. In Australia, the scaffolds are covered in Construction Work, Code of Practice that covers the full spectrum of the scaffold that includes Scaffold definition; Work health and safety duties; Managing risks; Before starting scaffolding work; Choosing a scaffold; Designing the scaffold; The system of work; Documentation; Competency and licensing; Inspecting scaffolds; and Types of scaffolds and scaffolding. The Construction regulations in South Africa cover the scaffold which made the contractor responsible for appointing a competent person in writing who must ensure that all scaffolding work operations are carried out under his or her supervision and that all scaffold erectors, team leaders and inspectors are competent to carry out their work. The above comparison of some of the key areas shows that GCC regulations are not up to the standards as applied in some advanced countries that display improved safety performance. GCC countries, therefore, need to consider the key areas which cause the accidents more frequently and developed up to date regulations for these areas. The top ten areas which need to be considered in the first stage are, fall protection, hazard communication standard related to chemicals, scaffolding and respiratory protection, control of hazardous energy, ladders, powered industrial trucks, training requirements, machinery, and machine guarding, and eye and face protection.

Similarly, all GCC countries need to work to rectify the ILO Occupational Safety and Health conventions.

The next section aims to provide a conclusion on the workers' health factors and body pain.

6.2.5 Construction Workers Health Factors and Body Pain:

Many studies have established that worldwide the construction workers are not at their health status. Such unhealthy workers display poor productivity and safety. There was however no study in the GCC region despite the fact that construction is major industrial and infrastructure projects are at peak these days. The mega infrastructure projects in the GCC region have provided employment opportunities to many workers from overseas. The worker's physical health in this study was assessed using some parameters including BMI, BP, and heart rate considering a total of 30 volunteers from the construction industry. The mix method which included field measurements, face-to-face interviews, and a structured questionnaire was used to achieve this. The mean values of age, BMI and sleeping hours of the respondents were 33.26 ± 8.95, 27.32 ± 3.17 and 7.21 ± 1.83 respectively. A total of 12 (40%) respondents were classified as non-smokers, 11 (37%) were classified as casual smokers and the remaining seven were classified as daily smokers. The BMI of 22 participants was more than 25; therefore they were classified as overweight or obese. Similarly, the blood pressure of 13 participants was considered to be in the rage of hypertension. The average sleeping hours of the participants were 4.5 hours. The result of this study further revealed that a total of 14 (out of 30) workers suffered from pain or discomfort in the last three months. The majority of the workers reported that they just ignore the pain. Productivity and sleep were among the highly affected area of the worker's daily life. The results clearly reported that the construction workers are not at their healthy condition and suffer from a variety of pains which affect their daily life. This situation can be changed considering some factors that are related to the workplace, diet, and a balanced lifestyle. As discussed earlier, the majority of construction workers in all GCC countries are from South Asian countries. They normally live in companies provided accommodation. The construction organizations need to ensure that these accommodations are up to the required standards and are equipped with all required facilities. The construction organizations also need to ensure that during the break hours necessary facilities are provided to the workers and they have an appropriate place where they can take their rest during the break hours. There is also a need for legislation in all GCC countries to regulate overtime and maximum working hours. Such legislations need to particularly ensure that the workers should not work more than 40 hours per week and that overtime should be the choice of the workers rather than the employers. Similarly, the construction organizations need to consider the weekly food menu for their workers as one of the nest solution to control the BMI and BP is healthy food. Since smoking is considered as one of the reasons for high BP; construction organizations and government agencies need to work together to reduce the smoker in the industry. Government agencies can play their role by raising the duty on tobacco products and creating awareness on the side effects of smoking. Construction organizations can ban smoking at workplaces and accommodations and putting penalties on the violators. One of the areas which need to be considered by all the stakeholders is that most of the overseas workers live in GCC countries without their families. They use to visit their families once in two years. These workers cannot bring their families in these countries due to the low income or some local regulations which don’t allow these workers to bring their families. In such a situation when these workers are away from their families for an extended period, Social and emotional problems generate which negatively affect the worker's life.

This was an initial study which has considered the workers’ health and body pain using a limited number of the participants. Such studies need to be carried out on a large scale so that the overall picture related to the workers’ health and body pain becomes clearer. Different approaches as discussed in this research need to be applied and the change in workers’ health and body pain needs to be monitor so that the most effective solution could be reached.

The conclusion on the safety climate factors identified in this research and on the tool developed is presented in the next section.

6.2.6 Safety Climate Factors and Safety Climate Tool:

The approach of safety culture and safety climate has attracted the attention of both academics and practitioners since 1980. There has been several safety climate assessment tools developed in some advanced countries, but in most cases, the base for these tools was not the construction industry. Overall, the assessment of safety climate provides an idea to the decision-makers to which area they need to focus to improve their safety performance. Such assessment helps the organizations to measure the existing maturity level of their safety climate and then make plans to achieve the required level of maturity of safety climate. In this part of the research, an attempt was made to develop a safety climate tool for the GCC construction industry considering its own parameters. A mixed research method consisting of literature, review, semi-structured interview and using a structured questionnaire was used to achieve the aim of this research. Data was collected using internet search (N = 14), semi-structured interview (N = 20), survey questionnaire (N = 102) and email interview (N = 19). The collected data was analyzed using SPSS. A safety climate assessment tool was developed considering the results obtained from the analyzed data. The developed tool has a total of seven factors including; aligning and integrating safety as value, training at all levels, improving site safety leadership, management commitment, empowering and involving workers, ensuring accountability, and improving communication.

Each dimension is supported by some statements which the respondents have to answers using a Likert scale of 1 to 5. The assessment tool is currently available in paper form; however, construction organizations can translate it to the electronic version particularly in a mobile application which would be helpful to reduce the language barriers of the respondents. The assessment tool developed in this research was validated using a qualitative research method in which the views of construction industry professionals were sought through email interviewing. Although the newly developed tool was appraised from the selected group managers working in different construction organizations, it is still important to monitor the effectiveness of the tool on a long term basis. It is expected that the status and maturity of GCC construction will be enhancing in the near future, therefore the safety climate factors which are significant now may not be significant in the future. A review cycle for the current tool after each five is recommended. It is still not clear how small and medium construction organizations limited resources could be benefited from this tool. Since most of the construction organizations in the GCC region can be classified as small and medium enterprises, therefore further research in this area is therefore recommended to see how the safety climate approach will benefit such organizations.

The study carried out in this research results in some recommendations, both in relation to improve the safety in construction and for further research in several areas. These recommendations are provided in the next section.

6.3 Recommendations:

The recommendations presented in this section are associated with different areas of the study carried out in this research project. Considering this, the recommendations are provided separately with each area of the research. The first section provides recommendations related to the causes of accidents.

6.3.1 Recommendations: Causes of Accidents:

The tracing model developed for the root causes of accidents presented in section 4.2 of chapter 4 was validated through its application on the accidents of a highway project jointly executed by two general contractors in Oman. Overall, it is a good practice for construction organizations to trace the causes of accidents using an appropriate tool. The tool developed in this thesis is simple which doesn't require expert knowledge to use it. Although, the model to trace the causes of accidents presented in this thesis is more appropriate for the highway project; however, it can be used in other projects as well provided the tool is properly validated. It could be a good practice to share the root causes of accidents with all stakeholders including workers, site supervisors, and management so that they know how many and what kind of accidents are directly linked with them and how they could improve in the future. It is not only enough to know the causes of accidents and the construction organizations should not stop at the stage, but they have to go further and develop a strategy to reduce these causes. Construction organizations also need to evaluate the effectiveness of their strategy. If a construction organization develops a strategy to reduce the accidents associated with workers, but after implementing this strategy, the number of accidents associated with workers is increased, thus this means that the strategy is not effective. The model to trace the root causes of the accident presented in this research will highly be influenced by statements workers and supervisors involved in the accidents. Construction organizations should ensure that the workers in their organizations feel free when providing such abatements. If they are under any kind of pressure, their statement will not be accurate and the actual cause of the accident will not be traced. The results of this research indicate that the construction organizations in Oman are reluctant to share the data related to the accidents as they feel it may damage the reputation of their company. In the presence of such practice and without the relevant raw data, research in the area of construction could not robust. Construction organizations, therefore, need to cooperate in such research. Many countries such as USA, UK, AUS, and SA are highly benefited from the independent organization that collects the accident data which easily available on that organization website. The establishment of such an organization in Oman is highly recommended to facilitate the research not only in the area of accidents but also in other areas of construction safety.

The next section provides recommendations related to the costs of accidents.

6.3.2 Recommendation: Cost of Accidents:

The costs of accidents presented in this research were based on the costs of accidents in the USA, UK, AUS, and SA. As discussed in section 6.2.2, the research suffered from the lack of cooperation from the insurance companies and construction organizations. Thus the main recommendation in this part of the research is that both the insurance companies and construction organizations need to cooperate in such research. Both the insurance companies and construction organizations contacted for the data did not cooperate in this research due to different reasons. The most common reason was the reputation of the organizations. Their busy schedules and the normal workload were also among the reasons. There have to be some regulations where it has to be mandatory that organizations should provide data for research purposes. Of course, it should also be made mandatory that research organizations and researchers should not reveal the name of the organizations so that the reputation of the organizations could not be affected. In an ideal situation, such data may be available publicly on the website of relevant government organizations. Such a government organization needs to ensure that the data is true and reliable. As discussed in section 1.1.1 of chapter 1, the accident data related to Saudi Arabia appears not to be accurate. The research based on such data could not be reliable; therefore it is very important that the data presented on the websites of such organizations should be true and reliable.

The next section aims to provide recommendations for heat stress.

6.3.3 Recommendations: Heat-Stress:

Although a list of the recommendations focuses on how to protect workers from the effect of heat-stress is provided in section 4.7.4 of chapter 4, however, since the results of the research in relation to the heat-stress presented in section 4.4.3 reveals that the values of the BMI and BP of the workers elevated, thus the effect of heat-stress on such workers could be more than the normal workers. In this regard it is important to follow the recommendations mentioned in section 6.4.1, however, it is also important that the workers should be physically healthy and their BMI and BP should be in the normal range. A balanced diet, healthy lifestyle, improved accommodation, workplace facilities, workload distribution and control on tobacco product are some of the key factors which could be helpful to control both BMI and BP. The government, organizations and the workers have responsibilities in this respect. For instance, the balanced diet, improved accommodations, workplace facilities, and workload distribution is directly linked to the organizations and they should take responsibility. The government develops standards with all these areas and through inspections ensures that organizations comply with all the relevant standards. Both the government and the organizations can play their role in the control of tobacco products; however, it is more dependent on the worker's choice.

The next section provides recommendations on Occupational Safety and Health Regulations.

6.3.4 Recommendations: Occupational Safety and Health Regulations:

Recommendations related to Occupational Safety and Health Regulations are derived from the literature review (section 2.6) and results and analysis presented in section 4.5. The current regulation has some limitations when compared with the regulations adopted by the USA, UK, AUS, and SA. The current Occupational Safety and Health Regulations discussed in section 2.6 of chapter 2 need to be review and amend based on the results and analysis presented in section 4.5 of chapter 4. It is important that the government develop separate regulations applicable to construction on the pattern of the regulations available in the USA, UK, AUS, and SA. To compare the current regulation with advanced countries, this research considered the top 3 causes of accidents mentioned in section 3.3.4. The remaining causes of accidents and its relevant regulations need to be considered in further studies. To develop new regulation or amend the current one, it is important to involve all the stakeholders including the construction organizations, labour unions, relevant societies, and government agencies. Such involvement and consultation will result in more effective and robust regulation. As mentioned in section 4.2 (table 4.3), the number of inspections from different government organizations in a specific project spanning over a period of more than four years is quite low. The government needs to have an effective mechanism of enforcement so that the regulations can be implemented in a true letter and spirit. Similarly, are mentioned in section 4.7.3, the maximum number of working hours along with the provision of overtimes as described in the Oman Labor Law needs to be reviewed according to international standards and regulations. There are some pending ILO conventions as discussed in sections 4.5.4 and 4.7.5 which need rectification. The government needs to expedite the process to comply with the pending ILO convention. The arrangement of training and awareness programs for both the workers and employers to know the provisions of the regulation will help to improve the situations on the ground.

The next section provides recommendations related to the worker s health and body pain.

6.3.5 Recommendations: Workers health factors and Body Pain:

Based on the results of BMI and BP presented in section 4.4.3, much of the worker's volunteers for this study were not in their healthy status. This is an important factor which needs the attention of the individuals, organizations and the government. The recommendations provided in section 6.3.3 need to be considered in this situation to bring the workers into their healthy status. Similarly, as mentioned in section 4.6.3, a large number of workers suffered from body pain. This should be a major concern of the organizations as such workers affected with body pain will not be able to concentrate effectively on their work and safety. Furthermore, the results of the impact of pain on workers daily life presented in section 4.6.5 also reveal that it affects several daily activities including the productivity of workers. As discussed in section 4.7.7, the impact of pain, however, can be reduced by changing the worker's positions in a particular job or assigning a different work at a different interval. This will reduce the time for being the same posture and can thus relief in the pain in a specific area. The construction organizations, therefore, need to consider participatory ergonomics as discussed in chapter 4. Similarly, the literature review also suggests that workers don’t understand the effect of body pain on their daily life. It is therefore important the government and construction organizations provide training and awareness for workers to enhance their understanding of body pain. Such programs should also be provided for construction organizations that how they protect their workers from body pain and how this is important for construction organizations.

The next section presents some recommendations on the safety climate.

6.3.6 Recommendations: Safety Climate:

As mentioned in chapter 5, the research presented in this thesis is based on the results of the literature review, semi-structured interviews, and the data collected through the questionnaires. The collected data went through statistical analysis and based on the results a safety climate assessment tool was developed. Although some brief guidelines have been provided for construction organizations wishing to use this tool in section 5.5.1, there are few recommendations to be considered as well. For instance, the construction organizations need to ensure that the participants selected for safety climate assessment are free from pressure so that they can provide an accurate response to each element. The participants in safety climate assessment, therefore, need to be on a volunteer basis. It is more appropriate that for each group of the participants, the data should be processed separately. Similarly, as noted in section 5.5.1, the plan to improve the maturity level of a factor may vary from 3 to 12 months depending on the type of plans and the resources reserved for that plan. The strategy (plan) to improve the maturity level of each group may be different from each other. The safety climate factors identified and used in this tool may be review and amend on a regular cycle of five years so that the tool reflects the factors which are considered important by the industry.

6.4 Knowledge Contribution:

One of the key knowledge contributions of this thesis is the development of a model to trace the root causes of accidents in construction presented in section 4.2. Similarly, the thesis has developed the guidelines on how to protect construction workers from heat stress considering the Oman and GCC hot and humid climatic conditions. These guidelines will help to reduce the number of accidents in construction projects. These guidelines were developed based on the existing literature and the input from the construction workers in Oman. These guidelines are very closer to the actual situation on the construction sites in Oman as most of the construction workers who participated in the development process of these guidelines were involved in a construction accident. These workers confirmed that heat stress is one of the main reasons for the accidents at construction sites in Oman. Similarly, they provided their input in the development of the guidelines to protect construction workers from the heat stress in GCC environmental conditions. Of course, the OSHA general guidelines were also considered in the development of these guidelines, but the actual input is based on the data collected from the construction workers in Oman. The new guidelines are therefore expected to be more effective to reduce the impact of heat stress on the construction workers in Oman and other GCC countries. One of the other major contributions of the research presented in this thesis is the development of the safety climate assessment tool. There have been several tools developed in the advanced countries, but construction was only in focus in a few of them. This unique tool presented in appendix V is developed for Oman and other GCC countries considering the construction industry parameters of the region. During its development and validation process, not only the existing literature is considered but also the construction industry stakeholders in Oman that include the managers, supervisors, foremen and the general construction worker's input are taken into account. The tool is therefore unique not only because it is specifically developed for Omani and GCC construction industry but it also takes on board all the stakeholders. Most of the existing safety climate assessment tools which of course were developed based on the input from other industries considered management commitment as one of the top leading factors contributing to the organizations' safety climate, the management commitment however placed at number 4 in the safety climate tool developed in this thesis. The results of this thesis show that the safety climate approach is not used in Oman and other GCC countries, the use of the new safety climate assessment tool would be a good addition to the practices that are currently applied in this region. The results of interviews held with top managers in the leading construction organizations have confirmed that the tool can serve their purpose to improve the safety performance of the organizations and projects. The research has also investigated the workers' health and body pain and reveals that construction workers in Oman are not in their healthy status and suffered from different types of pain. The thesis also compared the occupational safety and health regulation in Oman and suggests the amendment so that it can be brought at par to the regulations applicable in the USA, UK, AUS, and SA. One of the key contributions reported in section 4.3 is the evaluation of the economic burden of the cost of accidents in Oman, Qatar and Saudi Arabia. The results on the cost of accidents will enforce the stakeholders to take necessary actions to reduce the number of accidents in construction. When the number of accidents in the construction industry will reduce, the cost of accidents will reduce.

The work presented here is of a Ph.D. thesis. The safety, in general, is a complex issue, particularly when it comes to construction. This thesis has attempted to bring the work together on some important aspects of the safety in construction but this is not the end. The research on construction safety needs to be continued.

6.5 Limitation of the Study:

Although the research presented here has many strengths and contributions as outlined in section 6.4, there are however a few limitations as well. These limitations are discussed in this section. First of all the research was suffered from the non-cooperation from the construction organizations and the insurance companies in Oman. This has somehow affected the study related to the cost of accidents and the causes of accidents. The true direct cost of accidents in the construction in Oman and other GCC countries was not established due to the lack of cooperation from construction and insurance companies and as results, the average costs of accident from the USA, UK, AUS, and SA was used to evaluate the cost of accidents in Oman, Saudi Arabia, and Qatar. The lack of cooperation from the construction organizations was also evident in the development of the root causes of accidents. As a result, the model developed to trace the causes of accidents in Oman is based on the data collected from two construction organizations jointly executing a highway project. Similarly, the study related to worker's health factors and body pain presented in this thesis is based on the results of 30 volunteers from Oman. Such studies, however, need to be carried out a much larger sample as identified in the literature review section 2.7. Similarly, the safety climate assessment tool is developed in the English language and as most of the workers in Oman and other GCC countries would not be able to read and write the English, the tool may need to be translated to their local languages. They may be benefited from the development of a mobile application. The safety climate assessment tool developed in this research was validated through email interviews held with construction professionals in Oman. The time and the scope of the research, however, did not permit to conduct the longitudinal study in this regard. Such studies are, however, recommended for further research in the next section.

6.6 Further Research:

There are some areas that need further research to advance knowledge and understanding. One of the areas is related to the health factors and the body pain of the workers. As noted in section 6.5, the sample size for such research needs to comparatively high. Such a study is therefore recommended on a larger sample. Similarly, as discussed in section 4.6.4, 22% of the workers just ignore the body pain. This area needs further investigations to know why they just ignore the pain. Finally, longitudinal studies are recommended on the safety climate assessment tool presented in this thesis so that the effectiveness of the tool can be measured.

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Appendix I: Ministerial Decision No.19/1982 [Regulation Coverage]

a. General provisions;

b. Dangers of machinery;

c. Working conditions (lighting, ventilation, drinking water, eating places, toilet facilities, sleeping quarters, fire);

d. Health hazards;

e. Safety supervisors for establishments employing 100 or more workers;

f. Accidents;

g. Construction work;

h. Hoisting and hauling machines;

i. Mines and quarries

Appendix II: Pain Experience Questionnaire

A: Respondent Information

Reference of respondent (Use A, B, C etc.) ---

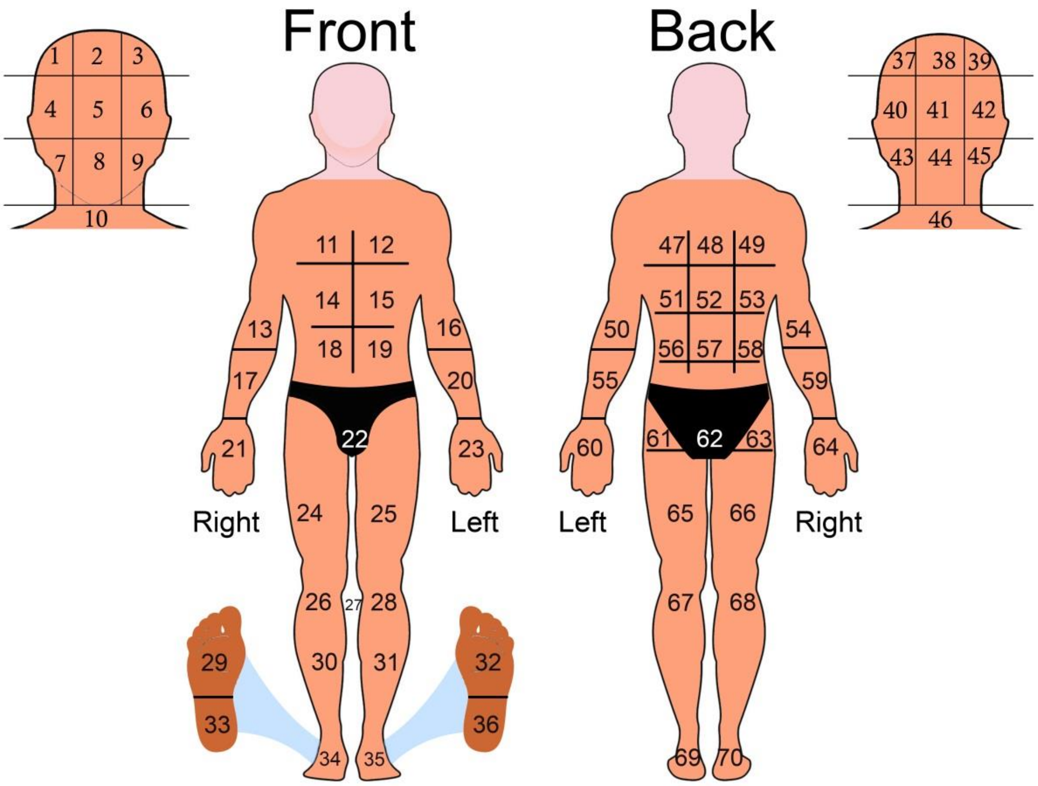
Reference of Respondent organization (Use 1, 2, 3 etc.) -------------------------------------

B: Have you experienced any pain including muscular, ligament, tendon, and joint discomfort or pain caused by work in the past three months. Tick √ the appropriate box.

1. YES 2. NO

(note: if your answer to question B is "NO", then you don't need to complete the remaining parts of this questionnaire.

C: Indicate your level of discomfort or pain in the below figure by circling the appropriate areas.



D: Rate the severity of pain symptoms you have felt over the past three months (1= very mild pain, 10 = unbearable pain). Tick √ the appropriate number.

1	2	3	4	5	6	7	8	9	10

E: Rate the severity of pain symptoms you felt over the past 24 hours (1= very mild pain, 10 = unbearable pain). Tick √ the appropriate number.

1	2	3	4	5	6	7	8	9	10

F: Rate the severity of pain symptoms you are feeling now if at all (1= very mild pain, 10 = unbearable pain) Tick √ the appropriate number.

1	2	3	4	5	6	7	8	9	10

G: Have you ever used any of the following pain treatment methods. Tick √ the appropriate methods? (it could be more than one).

1. Ignore the Pain ☐
2. Use of pain killers ☐
3. Use of Medical Cream ☐
4. Carried out massage ☐
5. Use of health product ☐
6. Use of physical therapy ☐
7. Doing exercise ☐
8. Use other treatment ☐

(Please indicate) ________________

H: Rate your response on the relief after treatment of pain. (0 = no remission, 10 = complete remission). Tick √ the appropriate number.

1	2	3	4	5	6	7	8	9	10

I: Rate the impact of the pain on your daily life. (1= strongly disagree, 5 = strongly agree). Tick √ the appropriate number.

1. Changed your mood.

1	2	3	4	5

2. Affected your walking ability.

1	2	3	4	5

3. Affected your work productivity.

1	2	3	4	5

4. Affected your relationship with partner, friends and family.

1	2	3	4	5

5. Affected your sleep habit.

1	2	3	4	5

6. Affected your Hobbies.

1	2	3	4	5

******************************End of Questionnaire***************************

Thank you very much for the response.

Appendix III: Safety Climate Questionnaire

PART I: PERSONAL / BACKGROUND INFORMATION

1. Your Year of Birth:

____

2. Your Gender:

☐ Male ☐ Female

3. You Position in Company:

☐ Manager ☐ Engineer ☐ Supervisor

☐ Foreman ☐ General Worker

☐ Any other (please write):

____

4. Your Highest Academic Qualification:

☐ Bachelor Degree ☐ Diploma ☐ Secondary Level

☐ Primary Level

☐ Any other (please write):

____

5. Your Experience in Construction Work:

☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ 21+ years

6. Your age group:

☐ 21-30 years ☐ 31-40 years ☐ 41-50 years ☐ 51-60 years ☐ 61+ years

7. Your country of birth:

____

PART II: MANAGEMENT COMMITMENT

Management commitment towards safety in construction organization can be demonstrated by;

S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	Defining safety expectation in policies, procedures, and guidelines; and communication of such policies, procedures, and guidelines across the organization	☐	☐	☐	☐	☐
2	Providing adequate resources to effectively implement safety activities	☐	☐	☐	☐	☐
3	Keeping safety is a top agenda item at all meetings of the organization	☐	☐	☐	☐	☐
4	Participation of management in all safety-related meetings of the organization	☐	☐	☐	☐	☐
5	Reflecting management visibility to workers and observing good on-site safety behaviors	☐	☐	☐	☐	☐
6	Providing sufficient safety training, and providing proper PPE	☐	☐	☐	☐	☐
7	Designing reward and incentive structures to encourage workers to actively participate in safety implementation	☐	☐	☐	☐	☐
8	Analyzing safety trends in the organization	☐	☐	☐	☐	☐
9	Conducting external audits evaluate safety performance	☐	☐	☐	☐	☐
10	Adopting a formalized process for corrective action	☐	☐	☐	☐	☐

PART III: ALIGNING AND INTEGRATING SAFETY AS VALUE

Alignment and integration of safety as a value in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1	Clearly defining and communicating the safety expectations in policies, procedures, and guidelines	☐	☐	☐	☐	☐
2	Adopting regular organization-wide safety communications to reinforce the culture of safety as a value (e.g., newsletters, alerts, leadership messages, safety topics, etc.)	☐	☐	☐	☐	☐
3	Recognizing employees at all levels for participation in safety activities	☐	☐	☐	☐	☐
4	Considering safety as a key-value through training for supervisors and workers	☐	☐	☐	☐	☐
5	Allowing different departments and groups to discuss project-related safety strategies	☐	☐	☐	☐	☐
6	Keeping safety as an agenda item for all production and planning meetings	☐	☐	☐	☐	☐
7	Aligning safety with productivity as a key-value	☐	☐	☐	☐	☐
8	Considering safety in hiring and promotion decisions	☐	☐	☐	☐	☐
9	Factoring Safety performance and engagement in safety activities into compensation	☐	☐	☐	☐	☐
10	Factoring safety into planning and bidding processes	☐	☐	☐	☐	☐
11	Using safety performance metrics as leading indicators for evaluations	☐	☐	☐	☐	☐

PART IV: ENSURING ACCOUNTABILITY AT ALL LEVEL

Accountability at all level in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1	Providing a perceive fair system	☐	☐	☐	☐	☐
2	Clearly defining and communicating safety expectations in policies, procedures, and guidelines, and communicating consistently across the organization (and to all business partners)	☐	☐	☐	☐	☐
3	Adopting an owner-controlled insurance program	☐	☐	☐	☐	☐
4	Enforcing safety policies and procedures in a consistent manner	☐	☐	☐	☐	☐
5	Benchmarking leading indicator data against other organizations	☐	☐	☐	☐	☐
6	Promoting and rewarding Incentive structures safety processes not (just) outcomes	☐	☐	☐	☐	☐
7	Conducting external audits to evaluate safety performance	☐	☐	☐	☐	☐
8	Factoring safety performance in the hiring of managers and subcontractors	☐	☐	☐	☐	☐
9	Making all members of the project team be responsible for safety activities	☐	☐	☐	☐	☐
10	Recognizing everyone for safety awards which are based on leading vs. lagging indicators	☐	☐	☐	☐	☐

PART V: IMPROVING SITE SAFETY LEADERSHIP

Safety Leadership improvement in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Incorporating safety in the strategic planning process	☐	☐	☐	☐	☐
2	Clearly defining safety roles and responsibilities at all levels of the organization	☐	☐	☐	☐	☐
3	Making workers be accountable for their safety responsibilities	☐	☐	☐	☐	☐
4	Ensuring supervisors lead by example	☐	☐	☐	☐	☐
5	Involving senior leaders in safety issues	☐	☐	☐	☐	☐
6	Promoting learning environment by leadership	☐	☐	☐	☐	☐
7	Providing training to supervisors in safety communication, motivation, and preplanning	☐	☐	☐	☐	☐
8	Encouraging Supervisors to attain a Safety Trained Supervisor credential	☐	☐	☐	☐	☐

PART VI: EMPOWERING AND INVOLVING WORKERS

Workers empowerment and involvement in safety in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Empowering workers through site orientations to actively participate in safety implementation	☐	☐	☐	☐	☐
2	Establishing a joint worker-management safety committee	☐	☐	☐	☐	☐

3	Involvement of workers in job hazard analyses	☐	☐	☐	☐	☐
4	regularly conducting Joint walkarounds to address specific problems raised by workers and others	☐	☐	☐	☐	☐
5	Frequently soliciting workers to share perceptions about safety implementation	☐	☐	☐	☐	☐
6	Encouraging workers to report potential hazards and injuries	☐	☐	☐	☐	☐
7	Ensuring that workers feel empowered with stop-work authority	☐	☐	☐	☐	☐

PART VII: IMPROVING COMMUNICATION

Improved communication in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Communicating policies and procedures effectively so that all workers understand them	☐	☐	☐	☐	☐
2	Ensuring that safety is included as an agenda item at every meeting	☐	☐	☐	☐	☐
3	Communicating organization materials in a consistent way that send a positive safety climate message	☐	☐	☐	☐	☐
4	Identifying informal leaders to help communicate safety messages	☐	☐	☐	☐	☐
5	Adopting a formal system for sharing close call and incident information	☐	☐	☐	☐	☐
6	Having a formal transparent process to address employee safety concerns	☐	☐	☐	☐	☐
7	Active engagement of management and	☐	☐	☐	☐	☐

	supervisors in a two-way conversation with workers about safety through joint worker-management committees, daily safety briefings, and joint walkarounds					
8	Ensuring that supervisors and management provide timely feedback on safety reports	☐	☐	☐	☐	☐
9	Mentoring safety	☐	☐	☐	☐	☐

PART VIII: TRAINING AT ALL LEVEL

Training at all level in a construction organization can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Providing safety training at all levels of the organization	☐	☐	☐	☐	☐
2	Encouraging supervisors to have certification in safety and heath	☐	☐	☐	☐	☐
3	Ensuring that safety leadership training is available for supervisors and foremen	☐	☐	☐	☐	☐
4	Providing and empowering peer training to workers	☐	☐	☐	☐	☐
5	Providing prevention through design training to in-house architects and engineers	☐	☐	☐	☐	☐
6	Providing joint safety committee training to all participants	☐	☐	☐	☐	☐
7	Encouraging all field workers to identify training needs, and develop materials	☐	☐	☐	☐	☐

PART IX: ENCOURAGING OWNER/CLIENT INVOLVEMENT

Owner/ client involvement in safety in construction can be demonstrated by;

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

1	Devoting adequate resources to safety implementation by owners	☐	☐	☐	☐	☐
2	Participation of owners in employees orientation, daily planning meetings, and wearing PPE (as appropriate)	☐	☐	☐	☐	☐
3	Regular visits by owners to connect with and learn from employees	☐	☐	☐	☐	☐
4	Presence of owner representative on-site to monitor and assist with safety implementation	☐	☐	☐	☐	☐
5	Use of Prevention through Design and Building Information Modeling in design and planning phases by owners	☐	☐	☐	☐	☐
6	Using safety performance as a prequalification for bids by owners	☐	☐	☐	☐	☐
7	Using leading indicators to evaluate bids by owners	☐	☐	☐	☐	☐
8	Supporting safety performance audits by owners	☐	☐	☐	☐	☐
9	Ensuring that workers don't get retaliation for raising safety concerns to the owners	☐	☐	☐	☐	☐
10	Giving workers a financial stake in maintaining safety when Owners participate in Owner Controlled Insurance Programs	☐	☐	☐	☐	☐

PART X: SAFETY CLIMATE FACOTRS (RELEVANCE)

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	Management commitment towards safety has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐

2	Aligning and integrating safety as value has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
3	Ensuring safety accountability at all level has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
4	Improving site safety leadership has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
5	Empowering and involving workers in the safety-related decision has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
6	Improving safety communication has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
7	Safety-related training at all level has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐
8	Encouraging owner/client involvement has a high influence on the safety climate of construction organizations	☐	☐	☐	☐	☐

PART XI: COMMENTS

If you wish to elaborate on some of your answers, or if you have any comments regarding the study, you are welcome to write them here

Thank you very much for your time.

Appendix IV: Ethical Approval letter

London South Bank University
EST 1892

103 Borough Road London SE1 0AA
T +44 (0)20 7815 7815 lsbu.ac.uk

Direct line: 0208 815 7264
E-mail: kaluaray@lsbu.ac.uk
Ref: RME1

29th November 2018

Dear Tariq Umar,

Re - Improving Safety Performance in Construction

Thank you for submitting this proposal for ethical review.

I am pleased to inform you that I, Dr Yamuna Kaluarachchi, on behalf of the School of the Built Environment & Architecture, have given full Chair's approval for your review.

I wish you every success with your research.

Yours sincerely,

Y D

Yamuna Kaluarachchi

Chair, Research Ethics Coordinator
School of the Built Environment & Architecture
London South Bank University

Appendix V: Safety Climate Assessment Tool

Safety Climate Assessment Tool

جـامـعـة الـشـرقـيـة
A' SHARQIYAH UNIVERSITY

London South Bank University
EST 1892

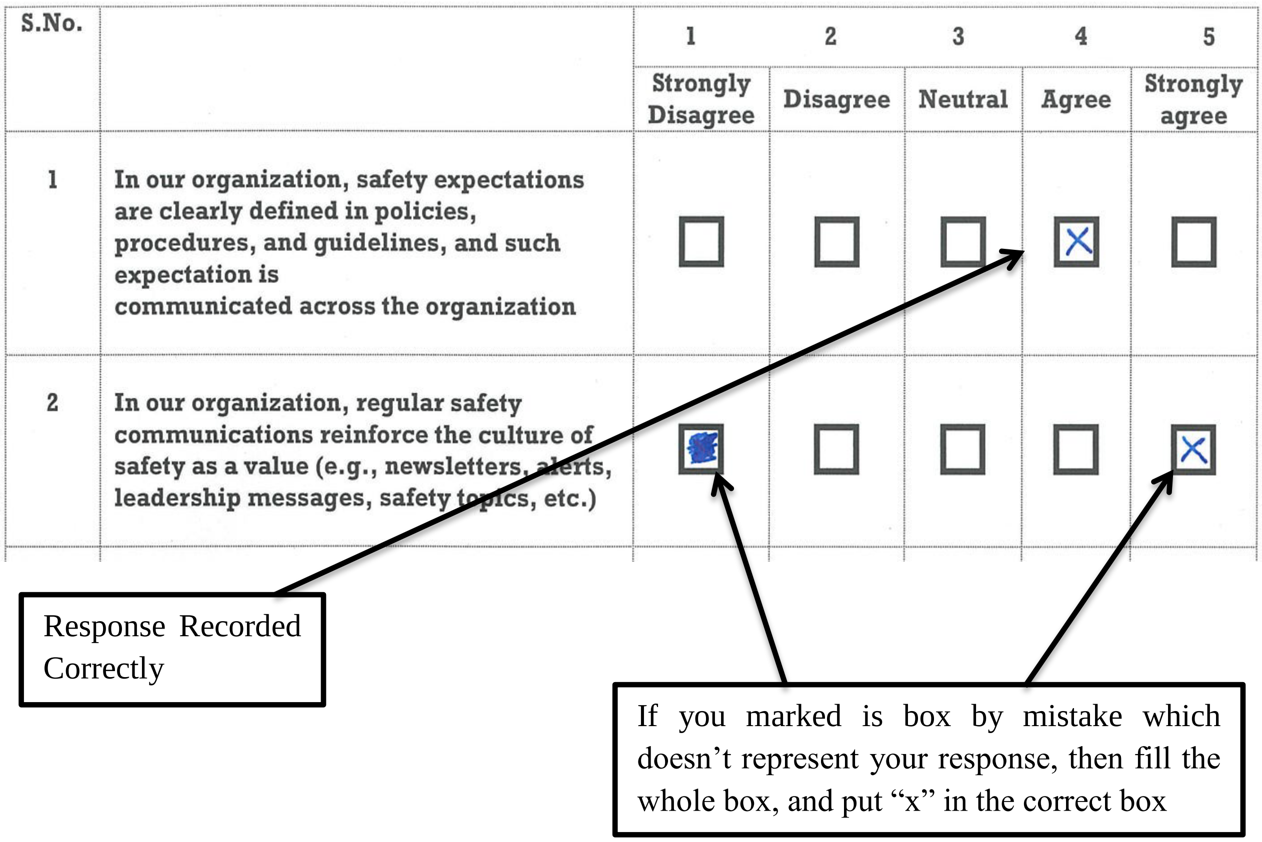
Information for the Respondents

1. The purpose of this tool is to get your view on the safety climate of this organization / project.
2. Your responses will be processed on a computer and will be handled confidentially.
3. No individual results will be presented in any way.
4. It is desirable to answer each and every question; but you have the right to desist from answering any one particular question, a group of questions, or the entire questionnaire.
5. If you need any assistance in completing this questionnaire, please ask you supervisor / manager for assistance.
6. If you need any further information, please contact your supervisor / manager and he/she would be happy to provide all the required information.
7. If you have chosen to participate in this study, please complete the consent section mentioned below.
8. To record your response of the tool correctly, please see the example on the next page.

I have read the above introduction to the questionnaire and agree to complete the questionnaire on volunteer basis	☐**Yes**

<u>How to Enter Your Response Properly</u>

1. Select only one response for each question and mark "x" in the correct box of your response.
2. If you marked "x" in a wrong box, then fill the whole box and put "x" in the correct box.



S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	In our organization, safety expectations are clearly defined in policies, procedures, and guidelines, and such expectation is communicated across the organization	☐	☐	☐	☒	☐
2	In our organization, regular safety communications reinforce the culture of safety as a value (e.g., newsletters, alerts, leadership messages, safety topics, etc.)	■	☐	☐	☐	☒

Note: This safety climate assessment tool is developed by a PhD student as part of his study held at London South Bank University, UK. In case of any assistance required, please contact the Doctoral student at <u>tariqumar1984@gmail.com</u>.

PART I: PERSONAL / BACK GROUND INFORMATION

1. Your Year of Birth:
____

2. Your Gender:

☐ Male ☐ Female

3. You Position in Company:

☐ Manager ☐ Engineer ☐ Supervisor

☐ Foreman ☐ General Worker

☐ Any other (please write):
____

4. Your Highest Academic Qualification:

☐ Bachelor Degree ☐ Diploma ☐ Secondary Level
☐ Primary Level
☐ Any other (please write):
____

5. Your Experience in Construction Work:

☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ 21+ years

6. Your age group:
☐ 21-30 years ☐ 31-40 years ☐ 41-50 years ☐ 51-60 years ☐ 61+ years

7. Your country of birth:
____

PART II: ALIGNING AND INTEGRATING SAFETY AS VALUE

S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	**In our organization, safety expectations are clearly defined in policies, procedures, and guidelines, and such expectation is communicated across the organization**	☐	☐	☐	☐	☐

2	**In our organization, regular safety communications reinforce the culture of safety as a value (e.g., newsletters, alerts, leadership messages, safety topics, etc.)**	☐	☐	☐	☐	☐
3	**In our organization, workers at all levels are recognized for participation in safety activities**	☐	☐	☐	☐	☐
4	**In our organization, safety as a key-value is reinforced through training for supervisors and workers**	☐	☐	☐	☐	☐
5	**In our organization, different departments and groups are able to discuss project-related safety strategies**	☐	☐	☐	☐	☐
6	**In our organization, safety is an agenda item for all production and planning meetings**	☐	☐	☐	☐	☐
7	**In our organization, safety is aligned with productivity as a key-value**	☐	☐	☐	☐	☐
8	**In our organization, safety is considered in hiring and promotion decisions**	☐	☐	☐	☐	☐
9	**In our organization, safety performance and engagement in safety activities are factored into compensation**	☐	☐	☐	☐	☐
10	**In our organization, safety is factored into planning and bidding processes**	☐	☐	☐	☐	☐
11	**Our organization uses safety performance metrics as leading indicators for evaluations**	☐	☐	☐	☐	☐

PART III: TRAINING AT ALL LEVEL

S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	In our organization, safety training is provided at all levels and is ongoing	☐	☐	☐	☐	☐
2	Our organization encourage supervisors to have certification in safety and health	☐	☐	☐	☐	☐
3	In our organization, safety leadership training is available for supervisors and foremen	☐	☐	☐	☐	☐
4	Empowerment and peer training is provided to workers in our organization	☐	☐	☐	☐	☐
5	Prevention through design training is provided to in-house architects and engineers of our organization	☐	☐	☐	☐	☐
6	Joint safety committee training is given to all participants of our organization	☐	☐	☐	☐	☐
7	In our organization, all field workers help to identify training needs and develop materials	☐	☐	☐	☐	☐

PART IV: IMPROVING SITE SAFETY LEADERSHIP

S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	In our organization, safety is included in the strategic planning process	☐	☐	☐	☐	☐
2	In our organization, safety roles and responsibilities are clearly defined at all levels of the organization	☐	☐	☐	☐	☐
3	In our organization, workers at all levels	☐	☐	☐	☐	☐

	are held accountable for their safety responsibilities					
4	**In our organization, supervisors lead by example**	☐	☐	☐	☐	☐
5	**In our organization, senior management is visible on safety-related issues**	☐	☐	☐	☐	☐
6	**In our organization, leadership promotes a learning environment**	☐	☐	☐	☐	☐
7	**In our organization, supervisors are provided with and required to take training in safety communication, motivation, and preplanning**	☐	☐	☐	☐	☐
8	**In our organization, supervisors are required to attain a Safety Trained Supervisor credential**	☐	☐	☐	☐	☐

PART V: MANAGEMENT COMMITMENT

S.No.		**1**	**2**	**3**	**4**	**5**
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	**Our organization define safety expectation in policies, procedures, and guidelines; and communicated safety expectation across the organization**	☐	☐	☐	☐	☐
2	**Our organization Provide adequate resources to effectively implement safety activities**	☐	☐	☐	☐	☐
3	**In our organization safety is a top agenda item at all meetings**	☐	☐	☐	☐	☐
4	**In our organization management participate in all safety-related meetings**	☐	☐	☐	☐	☐
5	**In our organization, management is visible to workers and observes good on-**	☐	☐	☐	☐	☐

	site safety behaviors					
6	**In our organization, workers receive sufficient safety training and have proper PPE**	☐	☐	☐	☐	☐
7	**In our organization, management designs reward and incentive structures to encourage workers to actively participate in safety implementation**	☐	☐	☐	☐	☐
8	**In our organization, safety trends are properly analyzed**	☐	☐	☐	☐	☐
9	**In our organization, external audits are conducted to evaluate safety performance**	☐	☐	☐	☐	☐
10	**In our organization, there is a formalized process for corrective action**	☐	☐	☐	☐	☐

PART VI: EMPOWERING AND INVOLVING WORKERS

S.No.		1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
1	**In our organization, site orientations empower workers to actively participate in safety implementation**	☐	☐	☐	☐	☐
2	**A joint worker-management safety committee exists in our organization**	☐	☐	☐	☐	☐
3	**In our organization, workers are involved in job hazard analyses**	☐	☐	☐	☐	☐
4	**In our organization, joint walkarounds are regularly conducted and focus on addressing specific problems raised by workers and others**	☐	☐	☐	☐	☐
5	**In our organization, workers are frequently solicited to share perceptions about safety implementation**	☐	☐	☐	☐	☐
6	**In our organization, workers are encouraged and unafraid to report**	☐	☐	☐	☐	☐

	potential hazards, near miss and injuries					
7	In our organization, workers feel empowered with stop-work authority	☐	☐	☐	☐	☐

PART VII: ENSURING ACCOUNTABILITY AT ALL LEVEL

S.No.		1	2	3	4	5
		Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1	In our organization, the system is perceived as fair	☐	☐	☐	☐	☐
2	In our organization, safety expectations are clearly defined in policies, procedures, and guidelines, and communicated consistently across the company (and to all business partners)	☐	☐	☐	☐	☐
3	Our organization have adopted an owner-controlled insurance program	☐	☐	☐	☐	☐
4	In our organization, enforcement of safety policies and procedures remain consistent	☐	☐	☐	☐	☐
5	In our organization, leading indicator data is benchmarked against other organization and internal continuous quality improvement	☐	☐	☐	☐	☐
6	Our organization promote incentive structures and reward safety processes not (just) outcomes	☐	☐	☐	☐	☐
7	External audits are conducted in our organization to evaluate safety performance and are based on leading as well as lagging indicators	☐	☐	☐	☐	☐
8	In our organization, safety performance is a primary factor in hiring managers and subcontractors, and for promotions	☐	☐	☐	☐	☐
9	In our organization, all members of the project team are responsible for safety	☐	☐	☐	☐	☐

	activities					
10	**In our organization, everyone is recognized and included in safety awards which are based on leading vs. lagging indicators**	☐	☐	☐	☐	☐

PART VIII: IMPROVING COMMUNICATION

S.No.		1	2	3	4	5
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1	**In our organization, policies and procedures are well communicated and all workers understand them**	☐	☐	☐	☐	☐
2	**In our organization, safety is included as an agenda item at every meeting**	☐	☐	☐	☐	☐
3	**Our organization materials communicate a consistent positive safety climate message**	☐	☐	☐	☐	☐
4	**In our organization, informal leaders are identified to help communicate safety messages**	☐	☐	☐	☐	☐
5	**There is a formal system in our organization for sharing close call and incident information**	☐	☐	☐	☐	☐
6	**In our organization, there is a formal transparent process for how worker safety concerns will be addressed**	☐	☐	☐	☐	☐
7	**In our organization, management and supervisors actively engage in a two-way conversation with workers about safety through joint worker-management committees, daily safety briefings, and joint walkarounds**	☐	☐	☐	☐	☐
8	**In our organization, supervisors, and management provide timely feedback on safety reports**	☐	☐	☐	☐	☐

9	**Mentoring safety is practiced in our organization**	☐	☐	☐	☐	☐

PART IX: COMMENTS

If you wish to elaborate on some of your answers, or if you have any comments regarding the study, you are welcome to write them here

Thank you very much for your time.

Appendix VI: Research Publications

1. Journal Publications:

1. **Tariq Umar** (2016). "Defining Safety Leadership in Construction" Proceedings of the Institution of Civil Engineers "Municipal Engineer". **170(1):** 3-5. https://doi.org/10.1680/jmuen.16.00004. ISSN: 0965-0903.

2. **Tariq Umar** and Sam Wamuziri (2016). "Using 'Safety Climate Factors' to Improve Construction Safety" Proceedings of the Institution of Civil Engineers: **Municipal Engineer**. https://doi.org/10.1680/jmuen.16.00020. ISSN: 0965-0903.

3. **Tariq Umar** (2017). "Cost of accidents in the construction industry of Oman". Proceedings of the Institution of Civil Engineers: **Municipal Engineer**. https://doi.org/10.1680/jmuen.16.00032. ISSN: 0965-0903.

4. **Tariq Umar** and Chalres Egbu (2018)**.** "Causes of Construction Accidents in Oman". **Middle East J. Management**, Vol. 5, No. 1, pp.21–33. http://doi.org/10.1504/MEJM.2018.10009611. ISSN 2050-3636

5. **Tariq Umar** (2018)**.** "Causes of delay in Construction Projects in Oman". **Middle East Journal of Management**. https://doi.org/10.1504/MEJM.2018.091132. ISSN 2050-3636.

6. **Tariq Umar**, Charles Egbu, Sam Wamuziri and Mohamed Shaik (2018). "Occupational Safety and Health Regulations in Oman". Proceedings of the Institution of Civil Engineers: **Management, Procurement and Law**. https://doi.org/10.1680/jmapl.18.00007. ISSN 1751-4304.

7. **Tariq Umar** and Charles Egbu (2018). "Perceptions on Safety Climate: A Case Study in the Omani Construction Industry". Proceedings of the Institution of Civil Engineers: **Management, Procurement and Law**. https://doi.org/10.1680/jmapl.18.00001. ISSN 1751-4304.

8. **Tariq Umar and** Chlares Egbu (2018). "Heat Stress, a Hidden Cause of Accidents in Construction". Proceedings of the Institution of Civil Engineers: **Municipal Engineer**. https://doi.org/10.1680/jmuen.18.00004. ISSN: 0965-0903.

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3. **Tariq Umar** and Sam Wamuziri "A Review of Construction Safety, Challenges and Opportunities – Oman Perspective". In Y G Sandanayake, G I Karunasena, and T Ramachandra (Editors). Proceedings of 5th World Construction Symposium 2016, 29-31 July **2016**, Colombo, **Sri Lanka**. Pages 14-22, ISSN 2362-0919.

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