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Sudan University of Science &Technology

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"Factors affecting safety performance on construction sites in Sudan"

العوامل المؤثرة علي أداء السلامة في مواقع التشييد في السودان

A Thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Civil Engineering- Construction Engineering

By

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Dedication

This thesis is dedicated to:

- My father, mother for their endless support
- My Brother, Sisters
- And to all my friends

Acknowledgement

All praises are due to Allah, Subhaanahu Wata'aala, for His Blessing on me and members of my family. I feel privileged to glorify His name in the sincerest way through this small accomplishment. I seek His mercy, favor, and forgiveness. I ask Him to accept this little effort as an act of worship. May the Peace and Blessing of Allah be upon His Prophet, Mohammed (Salla Allah Alaehi Was- Sallam)

I would like to thank my supervisor, Dr. Alia Osman Mohamed Ahmed, for the useful comments, remarks, encouragement and advice she has provided throughout my time as her student. I have been extremely lucky to have a supervisor who cared so much about my work.

I would also like to thank Sudan University of Science & Technology for providing me all the necessary support for this research.

ABSTRACT

The construction industry is considered one of the most hazardous industries, not only in developing countries but also throughout the world due to its unique nature. This makes more attention to construction safety to improve the safety performance of construction companies. This research aims to identify the factors affecting the construction safety and to establish rules to assess and improve the construction safety of construction companies. The questionnaire design is composed of three parts to accomplish the objective of the research as follow: General information of company and respondent; information of safety in company; factors affecting the safety performance in construction sites. Seventy-two sub factors were identified and grouped into eighteen main factors. A field survey was conducted through a questionnaire including construction companies in Sudan.

The collected data were analyzed by using the commercially available statistical package using for social science (SPSS) for manipulation and analyzing the data. The analyzed data include the description analysis includes: frequencies, means, Importance index was calculated to rank the safety factors.

The results showed that the most important main factors affecting the safety performance in Sudan from the eighteen ones are; these six factors as follow: 1- personal protective equipment

2- signs, signals and barricades; 3- crane and lifting equipment

4-Administrative & Management commitment; 5-Project Nature

6- excavation, trenching, and shorting;

Based on this study rules should be developed for easy use and to asses and improve the safety of the construction companies. Finally, from this research recommendation were derived in order to improve the safety performance of construction companies, with a set of recommendations for future work and studies.

المستخلص

يعتبر قطاع التشييد واحد من أخطر قطاعات العمل ليس فقط في الدول النامية ولكن علي المستوى العالمي، وأصبح من الضروري اعطاء أهمية قصوى للسلامة المهنية في هذا القطاع من أجل تحسين أداء السلامة في شركات التشييد. وتستعرض هذه الرسالة العوامل التي تؤثر علي السلامة في السودان وكذلك ايجاد الية لتقييم وتحسين اداء السلامة في شركات التشييد.

تصميم الأستبيان يتالف من ثلاثة أجزاء من أجل تحقيق أهداف البحث كما يلي: معلومات عامة عن الشركة وعن الشخص الذي سوف يقوم بتعبئة الاستبيان ، معلومات عن السلامة في الشركات ، العوامل المؤثرة علي أداء السلامة في مواقع التشييد. واشتملت هذه الرسالة علي اثنتين وسبعين عنصر فرعي تم دمجها في ثمانية عشر عنصر رئيسى. تم القيام بمسح ميداني يشمل شركات التشييد في السودان.

تم تحليل البيانات المتحصل عليها باستخدام الأساليب الاحصائية المناسبة بواسطة برنامج الحزم الاحصائية للعلوم الاجتماعية . حيث رتبت العناصر المؤثرة علي اداء السلامة بناء علي مؤشر الأهمية ، وتم مناقشة الارتباط والتوافق بين اراء المشاركين في هذه الرسالة .

وأظهرت النتائج ان العوامل الرئيسية التي تؤثر علي اداء السلامة في السودان تتكون من ثمانية عشر عامل أهمها هذه العوامل الستة وهي :

1- استخدام معدات الحماية الشخصية، 2- استخدام الاشارات والعلامات والحواجز ، 3- اعمال الرفع، 4- التزام الادارة، 5- طبيعة المشروع ، 6- مراعاة اعمال الحفر.

وبناء علي هذه الدراسة وضعت توجيهات لتكون سهلة الاستخدام لتقييم وتحسين السلامة في شركات التشييد. ختاما ولتحسين أداء السلامة في شركات التشييد تم ذكر مجموعة من التوصيات ، مع مجموعة من التوصيات للعمل والدراسات المستقبلية.

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List of Abbreviations

ANSI	American National Standards Institute
HSE	Health and Safety Excusive
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
RII	Relative Importance Index
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
USA	United State of American

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Construction sites are generally complex and sometimes unsafe. They are complex because of extensive use of sophisticated plants, equipment, modern methods of construction, multidisciplinary and multitasked aspects of its project workforce. Generally, construction sites are still one of the most dangerous workplaces because of high incidence of accidents, (Teo et al, 2005). The construction industry is characterized by continual changes, bombardment of varying technologies, poor working conditions and need for coordination of different interdependent trades and operations. Due to the hazardous nature of work, safety is a serious problem in the industry, (Tam et al, 2004). Globally, the construction industry has a poor safety record and is disproportionately dangerous compared to other industries, advocated the idea that safety is no luxury but a necessity, (Fung et al, 2005).

The interest in safety awareness among construction companies has greatly increased in the past decade. This increased awareness in safety can be attributed to many factors. As an example, the construction industry has come to recognize the relationship between risk management and return on investment. The ever- increasing cost of medical treatment, convalescent care, and the potential for lawsuits all add up to higher insurance premiums, which in turn tend to have a negative impact on a company's profit. In addition, companies with high accident rate are often prohibited from bidding on a certain type of work. It is therefore, in the company's best interest to take whatever means necessary to manage safety on the work site, (Koehn et al, 1995).

Large size companies tend to more effectively deal with the construction management and its applications. Thus, safety management will be more applicable with the large construction companies, which have the managerial ability to deal with such issues. on the other hand In small to medium companies, safety programs are often very informal and unwritten (Tam et al, 2004).

1.2 SCOPE AND PROBLEM STATEMENTS

All over the world, construction industry is one of the most hazardous industries due to its unique and dangerous nature. Safety has always been a persistent problem in it. In the United States of America (USA), it was reported that the construction industry accounted for 20% of all occupational fatalities, when they made up only 5% of the USA' work force. In Kuwait, the industry accounts for 42% of all occupational fatalities while in Hong Kong the industry accounts for more than one third of all industrial accidents over the last 10 years. In Singapore,the construction industry takes up 29% of the total number of industrial workers, but the industry accounted for an un-proportionate 40% of the industrial accidents. These studies are among many others that show that the industry has a very poor safety performance record (Chua and Goh, 2004).

Workplace fatalities and injuries bring great losses to both individuals and societies. Petersen (1971) has summarized the problem in two points:
(1) people are the fundamental reason behind accidents and
(2) management is responsible for the prevention of accidents. The management failures represent the real and underlying causes of accidents (Fang et al, 2004).

However, safety is not a luxury, and may be considered as an important function to be used against unnecessary loss of property, injury, or death. Preventing occupational injuries and illness should be a primary concern of all employers. Especially in developing countries, there must be an effort to raise the level of awareness among both employees and employers of the importance of health and safety at work sites. Emphasis in both developing and developed countries should be placed on training and the utilization of comprehensive safety programs
(Koehn et al, 1995).

In Sudan less work concerning this issue was conducted. This research is an attempt to identify the factors affecting the construction safety in Sudan in order to provide rules for assessing the safety of large construction companies and accordingly improve it.

To reduce the number of accidents, injuries, and fatalities in the workplace, safety should be a top priority. Although the issue of workplace safety has historically been viewed as more of engineering problem, several researchers (Enshassi, 2003; Hassona, 2005) have increasingly acknowledged that management factors have also played an important role in workplace safety.Many Studies have been conducted to examine factors like safe scaffolding. However, little attention has been centered on the other several factors such as the influence of group processes, communication, decision making, leadership, degree to which management values workers and uses of signals and barricades.

1.3 SIGNIFICANCE OF THE STUDY

Accidents in any industry especially in construction tend to be costly in both human and financial terms. As safety is concerned with reducing rates of accidents and controlling or eliminating hazards at the work site, preventing accidents must be the first significant step towards safety improvement. There is a need to increase awareness and to exert pressure on companies for safety. Economical, social and governmental regulations are few factors responsible for this increased pressure. Identification and understanding of accident causation is a prerequisite for improving safety.

The accident is in turn invariably caused or permitted directly by the unsafe act of a person and a mechanical or physical hazard (i.e. unsafe condition). To avoid accidents, it is required to identify and eliminate unsafe acts and unsafe conditions, which could be achieved by regular assessment of safety on site, employee training and inspection.

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1.4 RESEARCH AIM

This research aims to improve safety performance in Sudan by the assessment factors affecting safety performance, and achieve the comprehensive goal to minimize the level of accidents and maximum level of benefits for labors.

1.5 RESEARCH OBJECTIVES

This study objectives to assess the safety performance including physical and safety climate of the construction companies in Sudan. construction companies will benefit from this when recognize the situation and identify the factors affecting the construction safety. Also help them to take the necessary precautions to control these factors before occurring and be aware of them when they occur during construction.

1.6 RESEARCH HYPOTHESIS

1. Assessing the level of safety practice in construction companies in Sudan
2. Identify the most important factors affecting safety performance in construction sites in Sudan.
3. Develop rules to asses and improve safety performance in construction Projects in Sudan.

1.7 RESEARCH LIMITATION

This research is limited to the following:

1. Construction contractors point of view, where safety is more likely to the responsibility of them.
2. Buildings, roads and water sewage works construction companies.
3. Large construction companies in Sudan that are qualified and registered in the contractors.

1.8 RESEARCH METHODOLOGY

The methodology followed to conduct the study includes many steps, which can be summarize as below:

1. Perform a review of literatures relating to the topic of this study. The objective of the review is to identify factors affecting safety performance in large construction companies and methods of safety performance measurement

2. Collect data via a questionnaire survey to evaluate factors affecting the safety performance identified in the literature review.

3. Perform analysis of data using appropriate statistical techniques. such as the commercially available software (SPSS).

4. Ranking the results according to their importance.

5. Report and discuss results and major findings to introduce conclusions and recommendations.

1.9 THESIS ORGANIZATION

This thesis includes five chapters, references and appendixes. They are presented as follow:

- *Chapter (1*) presents an introduction to the research. It includes the problem statement, the objective, the scope and limitations, the significance and the methodology of the study.

- *Chapter (2)* presents the literature review and the previous efforts and studies which have been made in the field of safety and the factors affecting the safety performance and about safety measurement.

- *Chapter (3)* discusses the research methodology which includes the information about the research design, research location, pilot study, questionnaire design.

- *Chapter (4)* presents and discusses data analysis, statistical methods used, tables and information deduced from statistical analysis and statistical results. The procedures for assessing and improving the safety performance and practice are discussed.

- *Chapter (5)* summarizes the results and major finding, to present the conclusions and recommendations of this research.

CHAPTER 2

LITERATURE REVVIEW

2.1 INTRODUCTION

Safety at work is a complex phenomenon, and the subject of safety attitudes and safety performance in the construction industry is even more so. In China construction industry the risk of a fatality is five times more likely than in a manufacturing based industry, whilst the risk of a major injury is two nd a half time higher. Unfortunately, it is not only construction workers who suffer from accidents but, on average, one member of the public, including children, is killed each month, (Sawacha, et al, 1999).

Safety can be considered as a common sense approach to removing agents of injury. The dictionary meaning of the word safety is the conditions of being safe from danger or risks (Baig, 2001).

Safety assessment is a process used to determine a contractor's compliance with or ability to meet specific safety rules and requirements set by the government safety regulations or by safety and environmental organizations. Safety rules or criteria are needed to accomplish the work with high overall performance. Any deviation from these safety requirements will affect the contractor's overall performance(Al-Amoudi, 1997).

2.2 HISTORY OF SAFETY

As proceed into the Middle Ages, more awareness of the link between the work that people did and the types of injuries and illnesses, which they suffered, was recognized. During this period the first unions began to be organized to try to protect workers from the hazards of the workplace. The only improvement in the 1800s was fire protection because of pressure from insurance companies (Reese, 2003).

During the first part of the 1900s, workers' compensation laws started appearing and were finally deemed constitutional by the Supreme Court in 1916. Prior to this most employers passed the blame and responsibility to their workers for workplace incidents using what were called "the common laws" which stated:

1. The employer was not responsible when a fellow worker caused your injury due to negligence.
2. The employer was not responsible if the worker was injured due to his/her own negligence.
3. If an employee took a job and knew that it was risky, or knew of the inherent hazards of the work prior to taking the job and was injured, the employer was not responsible.

Under the workers' compensation laws the employers assumed responsibilities for their workplaces' safety and health. They were required to provide and pay for medical care and lost wages due to on-the-job incidents.It was during this time that mining catastrophes continued to occur and more laws were passed to protect miners. When 2,000 workers or 50 percent of the work force died from silica exposure at Gauley Bridge, West Virginia, the Walsh-Healey Act was passed that required safety and health measures for any employer receiving a government contract. Some companies began to understand their moral responsibility, (Reese, 2003).

When management found itself in the problem, by legislation, of having to pay for injuries on the job, it decided that it would be financially better to stop the injuries from happening. This decision by the industry all over the world gave birth to the organized industrial safety movement.

Management concentrated heavily, if not entirely, on correcting the hazardous physical conditions that exist in the work place in the early years of the safety movement. This showed a significant decline in the death rate (deaths per million man-hours worked) during the first 20 years of the safety movement, (Petersen, 1971).

In December 1970 Congress enacted and President Richard Nixon signed the Wiliiams-Steiger Occupational Safety and Health Act (OSHAct), which became effective on April 28, 1971. It applied to more than 5 million businesses involved in or affecting interstate commerce and 60 million workers, (Hammer, 1985).

Recently, Safety standards and regulations are published by international and national organizations and are accepted by the construction industry. Among these are the Occupational Safety and Health Administration (OSHA) standards for the construction industry, the US Department of Energy safety regulations, and US Army Corps of Engineers safety and health requirement manual, (Kartam, et al, 2000).

Safety Via OSHA

The Occupational Safety and Health Act of 1970 (OSHA) is a comprehensive set of safety and health regulations, inspection procedures, and record keeping requirements. In the United States, the OSHA is the principal authority in charge for regulating occupational and health issues and also for providing safety related training to contractors, (Ahcoma, 2004).

OSHA organizes a series of training institute and education centers, which provides training specifically aimed to train safety professionals. The experience shows that many contractors are preferring, employees who have experienced OSHA training course. The large and small companies also prefer their employees acquainted with OSHA safety training course, (Ahcom, 2004).

2.3 IMPORTANCE OF SAFETY

The advancement in social sciences has promoted a greater awareness of the sanctity of life and the unacceptability of premature death due to accidents. Accidents at construction sites are identified as a major problem throughout the world. According to reports published by the construction industry institute, injuries and fatalities occur in the construction industry at a rate more than 50% higher than all other industries, (Kartam and Bouz, 1998).

According to Agarwal and Everett (1997), in the United States, the construction industry employs about 5% of the work force, but accounts for 11% of disabling occupational injuries and 18% of all occupational fatalities. These figures have changed in 1998 to be that construction industry employs about 6% of the work force, but accounts for 10% of occupational injuries and 21% of all occupational fatalities. (Everett, 1999).

Research on risk management perceptions and trends in US construction; shows that safety is considered to be one of the highest risk allocations, and is marked at 8.3 on a10 point scale. By assigning safety the highest importance rating, contractors believe that they have and will continue to have sole responsibility for this risk in the future, (Kartam, et al, 2000).

In their research on important criteria's for contractor selection, Hatush and Skitmore (1997) establish that, health and safety performance of contractors was among the top four important criteria's. Therefore, safety is a very important element in the success of any construction project. It has a major impact on the contractor, owner, workers, and on the environment. In many countries a contractor safety sheet or performance record is considered one of the items that qualify a contractor for a bid. Furthermore, many public agencies include safety standards as part of the construction contract documents, which then become a contractual obligation as well as a legal one, overall, the contractor must be concerned about the safety for the following reasons, (Bu Khamsin, 1999):

- **Humanitarian Concern**

  The suffering as a result of an accident both to injured parties and their families cannot be measured in economic terms. The contractor should never disregard this, even when the injured parties have been adequately compensated by insurance.

- **Economic considerations**

  The contractor must realize that even with adequate insurance coverage, accidents will reduce company profits through the increased costs of future insurance premiums.

- **Legal Considerations**

  OSHA requires that each employer provides to each of his employees a place of employment that is hazard free.

- **Company Image**

  A good safety record is a proven means of increasing worker morale and productivity. This in turn improves the company's public image, and therefore improves the company's bargaining position for negotiating future jobs.

2.4 CONSTRUCTION SAFETY IN MIDDLE EAST

The construction industry in Saudi Arabia employs 15% of the total labor force and accounts for 14% of the total energy consumption in the country (Jannadi and Bu Khamsin, 2002). In Arabic region, construction safety conditions resemble those in developing countries. In the construction industry, the working environment is constantly changing, sites exist for a relatively short time and the activities and inherent risks change daily (Kartam et al, 2000; Jannadi and Bu-Khamsin, 2002). It was found that higher frequencies of construction accidents occurred on projects that were over budget and those that were competitively bid (Kartam et al, 2000). Kartam et al (2000) summarized safety problems in Kuwait as follows: competitive tendering; lack of safety regulations; small size of most construction firms; extensive use of subcontractors; lack of relevant accident data; extensive use of foreign labor; disorganized labor; high labor turnover; low priority of safety; seasonal employment and weather effect Kartam et al (2000) in his research did not mention management in safety problems in Kuwait. Jannadi and Bu-Khamsin (2002) found in questionnaire that the most important three factors influencing safety performance are; (1) management involvement; (2) personal protective equipment; and (3) emergency/disaster planning and preparation. One of the most prevailing problems in Middle East counties is that workers and engineers receive almost no safety training and are mostly uninformed about the company's safety programs or policies (Kartam et al, 2000).

2.5 FACTORS AFFECTING SAFETY PERFORMANCE

Safe acts and safe conditions in performing construction works have been receiving broad attention in the construction engineering and management literature. Numerous authors and researchers have addressed various aspects of safety in the past years. Table 2-1 provides brief overviews of key safety researchers, (Jannadi,2001).

Table 2-1 Summary of Researches Relating to Safety (Jannadi. 2001)

Year	Authors	Summary of research	Key factors associated with safety success
1976	Levitt and Parker	Related to top management role in reducing construction accidents.	Company manager's awareness of safety problems.
			Evaluation of superintendents based on safety performance.
			Top managers pointedly talking about safety when they visited jobs and experienced modification rates (EMR) lower than companies in which this was not mentioned during interviews.
			Companies that conducted formal safety orientation for all new hires had average EMR lower than companies that had no formal orientation for newly hired workers
			Incentives based on lost-time accidents awarded to workers, foremen, and superintendents for accident-free work had no effect on safety, according to research findings.
			Crews were found to perform work quicker, better and more safely when managers insisted on detailed work planning (including materials, equipment, man power, and safety requirements) prior to the start of the job.
1978	Hinze	Identified safety impact of new worker and turnover rates.	Superintendents whose crews had fewer injuries where those having larger percentage of workers transferring with them from one job to the next.
			Safety increases when companies retain their employees for more than one year, and there are additional safety benefits when employees are kept for even longer periods of time (five years in this study).
1978	Hinze and Pannullo	Found that increased job control led to better safety performance.	General trends suggested more top-management visits per week lowered the injury index.
			Injuries tended to be lower in those firms engaging in projects in close proximity to the home office.
			Safety companies employed the same workers for a longer duration.
			Safety performance improved when more workers visited the home office regularly.
1978	Hinze and Parker	Investigated superintendent characteristics associated with improved safety performance.	Increased job-related pressure on superintendents led to increase injuries.
			Superintendents in strong support of job competition and those who only moderate supports of competition.
			Superintendents who were under pressure to complete the job from the home office had higher injury frequencies.
1979	Hinze and Francine	Investigated supervisor worker relationships and how they affect injury rates.	Supervisors who are more flexible in dealing with subordinate conflicts have better safety records compared to their more rigid counterparts.
			Safety performance is worse when foremen have full firing authority.
1981	Hinze and Harrison	Identified safety program practices in large companies associated with reduced injury frequency rates.	The corporate safety director hired the field safety representative.
			Field safety directors trained their subordinate workers.
			The safety director reported to the president or vice president of the company.
			New workers received formalized safety orientation.
			Safety awards were given to workers.
			Safety awards were given to foremen
1982	Samelson And Levitt	Identified owner's guidelines for selecting safe contractors.	Owners who involve themselves actively in selecting and monitoring safety performance of contractors have significantly lower accident rates on their construction
			Several owner strategies were found to have a significant impact on contractor safety: use of short-term worker permits to regulate hazardous operations; stressing safety during the pre-bid site visit; incorporating detailed job specific safety requirements in specifications and periodic inspections; maintenance for safety records; setting

Table 2-1 (Continued)

Year	Authors	Summary of research	Key factors associated with safety success
1982	Samelson And Levitt	Identified owner's guidelines for selecting safe contractors	ambitious goals for contractor safety and rewarding successful achievement of those goals; considering safety as a criteria in presenting contractors for bid lists; providing safety orientation and training materials for contractor's labor and supervision for hazardous operations unique to the particular project; and developing in-house owner construction safety personnel with the expertise to carry out their tasks.
			Actions such as requiring contractors to delegate safety to onsite personnel, examination of safety at job site meetings, and investigation of accidents were initiated by both safe and average owners.
			Placement of considerable emphasis on selection of safe contractors by the owner is necessary for fewer monitoring and control actions.
1988	Hinze and Reboud	Identified appropriate means of achieving or maintaining acceptable safety performance on large projects.	Employed a full-time company safety officer.
			Strong top-management support for safety.
			Safety meetings were conducted for supervisors.
			Supervisor safety performance was monitored.
			Specific job site safety tours were conducted.
			Safety issues were included in regular held coordination meetings.
			Lower incident rates occurred on projects that employed sophisticated scheduling techniques.
			Better safety results occurred when the owner or owner's representative was included in coordination meetings.
			Job pressures (particularly those imposed by budgetary constraints) were found to adversely affect safety performance.
1988	Hinze and Figone	Investigated specialty contractor safety as influenced by general contractors on small and medium-sized projects.	Superintendents who felt less project pressure had safer projects.
			Projects on or ahead of schedule were safer.
			Companies that emphasis other goals in addition to profits had safer projects than companies only seeking to maximize profit.
			Companies that negotiated a majority of their prime contracts had safer projects.
			Several variables related to job coordination affected safety positively, smaller projects; projects with fewer specialty contractors; companies that negotiated a majority of their subcontracts; and companies that use the same specialty contractors.
			Two variables related to company safety emphasis result in safer projects; companies whose home office monitors project safety, and concern by top management.
			Two variables related to superintendents' concern for workers result in safer project; superintendents who show concern for workers and superintendent who provide new worker orientation.
			Two variables related to job cleanliness result in safer projects; good housekeeping, and daily specialty contractor safety inspections.
1988	Hinze and Figone	Investigated specialty contractor safety as influenced by general contractors on large projects	Significant factors correlated with general contractor injury rates; conducting special safety meetings for field supervisors, and employing full-time safety professionals.
			Significant factors correlated with general contractor safety performance: specialty contractor was involved in project meetings with the owner; general contractor reported directly to the home office rather than the district office; general contractor reviewed specialty contractor safety programs or required them to follow project-wide safety programs: project schedules were prepared by superintendents or site scheduling department: and general contractor required the specialty contractor to hold 'toolbox" safety meetings.

Table 2-1 (Continued)

Year	Authors	Summary of research	Key factors associated with safety success
1988	Hinze and Figone	Investigated specialty contractor safety as influenced by general	Factors that tended to show a relationship to improved general contractor safety performance: the general contractor was not experiencing excessive schedule pressure; general contractors were located farther from their home office: and the general contractor investigated all specialty contractor accidents.
1993	Liska, et al.	Identified zero accident techniques Contractors on large projects.	Safety project/pre-task planning included safety goals, safety person/personnel, hiring employees, safety policies and procedures, fire protection program, accountability/responsibility, and safety budget concerns.
			Safety training and orientation required.
			Safety incentives provided.
			Alcohol-and substance-abused program in place.
			Accident and near-miss investigation conducted.
			Record keeping and follow-up undertaken.
			Safety meetings held.
			Personal protective equipment employed.

Many researches have been carried out in the literature in order to identify the factors affect the safety performance of construction projects. Table 2-2 shows the summary of these researches.

Table 2-2 Summary of Researches have been carried to identiy the Factors Affect Safety Performance in construction sites (projects)

Year	Author	Summary of research	Factors affecting safety performance in construction sites
1999	*Sawacha, et al.*	Identify factors influencing safety performance on construction sites	Management talks on safety.
			Provision of safety booklets
			Provision of safety equipment
			Providing safety environment
			Appointing a trained safety representative on site.
2001	*Jannadi, et al.*	Identify Safety factors considered by industrial contractors in Saudi Arabia	Site planning and housekeeping
			Welfare facilities
			Emergency /disaster planning and preparations
			Signs, signals and barricades
			Handing, storage and use of material
			Welding and cutting
			Concrete and concrete framework
			Crane and lifting equipment
			Chemical handing
			Electrical equipments
			Handling, transportation and disposal of hazardous materials and waste
			Personal protective equipment
			Fire prevention
			Transportation
			Excavation, trenching, shorting
			Scaffolding and ladders
			Hand and power tools
			Mechanical equipment
			Ionization radiation
			Management involvement

Table 2-2 (Continued)

Year	Author	Summery of research	Factors affecting safety performance in construction sites	
2004	*Fang, et al.*	Discussing an empirical research on workplace safety management performance on construction sites in China	Foremen related factors	Frequency of a crew's receiving safety inspection.
				Frequency of a foreman's presence in safety meeting.
				Frequency of a foreman's reporting safety related matters to manager.
				Frequency of a foreman's announcing safety related matters to workers.
				Frequency of a foreman's correcting workers unsafe actions.
			Worker related factors	Frequency of a worker's smoking on the site.
				Frequency of a worker's breaking safety regulations.
				Hours of safety education per year a worker receives.
				Frequency of a worker's partners reminding him of personal safety.
			Crew related factors	Frequency of a crew s receiving notices of hazard removal.
				Frequency of a crew s breaking safety regulations.
				Frequency of a crew's suffering safety penalty.
			Manger related factors	Frequency of a project manager s presence in safety meeting.
				Frequency of a project manager's hearing safety reports.
				Frequency of a project manager's discussing safety matters with subcontractors.
			Safety training related factors	Days of safety education per year a safety officer receives.
				Hours of safety education per year a foreman receives.
				Frequency of a foreman's reminding new workers of safety regulations.
				Ratio of workers whose occupational experience is less than 1 year to total workers on site.
2005	*Tam, et al.*	Identifying elements of poor construction safety management in China	Poor safety awareness of top management.	
			Lack of training.	
			Poor safety awareness of project managers.	
			Reluctance to input resources to safety.	
			Reckless operations.	
2005	*Ng, et al.*	Evaluating safety performance of construction contractors	At an organizational level	Implementation of safety management system in accordance with legislation.
				Compliance with occupational safety and health legislation, codes and standards.
				Definition of safety responsibility.
				Development of safety policy.
			At project level	Provision of safe working environment.
				Development of emergency plan and procedures.
				Development of safety committee.
				Definition of safety responsibility to all site personnel.
2005	*Fung, et al.*	Investigating the safety culture in Hong Kong construction industry	Effective accident reporting.	
			High line management commitment.	
			Active supervisor's role.	
			Active personal role.	

Table 2-2 (Continued)

Year	Author	Summery of research	Factors affecting safety performance in construction sites	
2005	*Teo, et al.*	Investigating how project managers may increase the safety levels of construction sites	Policy aspect	Understanding and implementation of safety management system.
				Understanding and participation in occupational health and safety management system.
				Understanding and implementation of permit-to-work system.
			Process aspect	Quality of subcontractors.
				Understanding and implementation of safety procedures.
				Carrying out work in a safe manner.
				Carrying out work in a professional manner.
				Type and method of construction.
			Personnel aspect	Management s attitude towards safety.
				Supervisors and worker s attitude towards safety.
				Contextual characteristics of workers.
			Incentive aspect	Monetary incentives.
				Non-monetary incentives.
				Disciplinary action.
2007	*Aksorn*	Evaluating Critical success factors influencing safety program performance in Thai construction projects	Clear and realistic goal	
			Good communication	
			Delegation of authority and responsibility	
			Sufficient resource allocation	
			Management support	
			Program education	
			Continuing participation of employees	
			Personal motivation	
			Personal competency	
			Teamwork	
			Positive group norms	
			Personal attitude	
			Effective enforcement scheme	
			Safety equipment acquisition and maintenance	
			Appropriate supervision	
			Appropriate safety education and training	

Year	Author	Summery of research	Factors affecting safety performance in construction sites
2007	*Hassan et al.*	Perception of Building Construction Workers Towards Safety, Health	Fire prevention
			Housekeeping
			Scaffold/mobile tower
			Sandblasting
			Cartridge operated tools
			Power tools/machine
			Excavation
			Heavy equipment
			Concrete formwork
			Gas/electric welding
			Health and welfare
			Compressed gas
			Transportation
			Air compressors

2.5.1 Project Nature

The nature of the project is supposed to have strong influence on safety performance. It includes the work environment, complexity of the design and type of owner.

2.5.1.1 Work environment

The aim in tide site planning and facilities is to produce a working environment that will maximize efficiency and minimize risks. Aspects of tide site that need to be addressed include access and traffic routes, material and storage handling, site offices and amenities, the construction plant, fabrication workshops, services and facilities, and the site enclosure. Previous research shows that tidy and well planned sites are more likely to provide a high level of safety performance. Workplace hazards may be defined as tangible factors that may pose risks for possible injuries or ailments. Within this definition, hazards do not always result in accidents, but they lurk in work environments, waiting for the right combination of circumstances to come together (Mohamed, 2002).

Mattila, et al. (1994) conducted a study to determine whether there is any connection between the quality of the work environment and occupational safety. The study was conducted at a construction company. Altogether 16 sites were included. The accidents were analyzed according to the company accident reports. A safety checklist was used to determine the safety level of the sites. The study proved that the quality of the work environment and the level of safety are directly connected in construction, and the high quality work environment will improve the housekeeping and reduce the accident frequency rates.

2.5.1.2 Design

In the development of a project, a significant role is played initially by the designer of the project and then by the constructor of the project. Construction worker safety has often been regarded the sole responsibility of the construction contractor. Despite the obvious reasons for placing: the primary responsibility on the contractor, the safety performance on a project may well dictated largely by decisions made by the designer (Hinze and Wiegand, 1992).

Through a questionnaire distributed to designers, it was found that 70% of the respondents did not address construction worker safety and health in their designs. Experience shows that the safety of construction workers cannot be guaranteed by legislation alone (Kartam, et al. 2000). Designers can play a strong role in reducing the incidence of injuries and fatalities among construction workers; they should accept this responsibility with a heartfelt commitment to provide in each design a safer workplace for the construction workers. Many construction workers have been severely injured and killed on construction projects, a dear price to pay for the opportunity to work in the construction industry. Designers should address construction worker safety in their designs (Hinze and Wiegand 1992).

Although the involvement of design professionals in construction site safety has been minimal to nonexistent, when they are involved their influence can be significant. It is the design that affects how a particular project and its components will be assembled and how construction tasks are undertaken. When engineers and architects are cognizant of and responsive to the safety consequences of their design decisions, safety improves. This leads to a reduction in injuries and associated costs and a decrease in redesign costs and in operating costs for special procedures and protective equipment (Hinze and Gambatese, 2003).

2.5.1.3 Owners

Owners have long recognized and honored a moral obligation to provide a safe work environment to minimize injuries. Owners can take measures to achieve better safety performance such as (Improving Construction Safety Performance, 1982):

- Provide safety and health guidelines that the contractor must follow
- Require the use of permit systems for potentially hazardous activities.
- Require the contractor to designate a responsible supervisor to coordinate safety on the site.
- Discuss safety at owner –contractor meeting.
- Conduct safety audits during construction.
- Require prompt reporting and full investigation of accidents.

Hinze and Gambtese (2003) in their research identified factors that significantly influence the safety performance of specialty contractors that safer worker performances were realized among those firms reporting that large percentage of their projects were with private owners.

2.5.2 Emergency Planning and Preparations

Effective emergency planning requires workers be familiar with emergency procedures before a crisis. It is the responsibilities of the contractors to ensure that all workers are familiar with the proper interaction against fire and other serious emergencies.

The potential for emergency exits at all construction sites and facilities and their associated costs can be devastating in terms of worker casualties, business interruption, loss of capital of investment, etc. These events can not be avoided but the contractors can reduce of the frequency of the occurrence and severity of damage with effective preparation and planning. This can be accomplished by developing emergency response plans that address immediate concerns within the contractor's operation. An emergency is an abnormal incident posting a threat to the safety of workers, the environment or property at a facilities or site. The emergency can be brought under control using the resource and procedures for emergency response in place for the facilities or site (Hislop, 1991).

2.5.3 Signs, Signals and Barricades

The contractors should establish a system of signaling for all operations in which signal are required to prevent danger, as far as practicable a uniform signaling system must be adapted for all constructions. The code of signals should be posted up at suitable places and also made available in the form of a handbook. In order to avoid danger, the contractor should take adequate steps to ensure that workers are familiar with all signals that they should know (Tam et al, 2003).

2.5.4 Historic, Human and Psychological Climate

The historic factor mainly indicates the safety related experiences of people on site, as human experiences influence their safe or unsafe actions and their involvement in safety on site.

Human behavior is very important, and it is difficult to control. Unlike engineering solutions, in which numbers are plugged into various formulae to solve specific problems, handling people requires situational leadership. Hazards cannot be solved and eliminated just through engineering control. They also need to be recognized by employees who will minimize their effects. However, human behavior cannot be programmed like a machine, (Jannadi, 1995).

The psychological climate has been shown to directly influence the safety performance of individual workers. This climate includes the workers' relationship with or the attitude toward fellow crew members, the supervisor, and the employing firm. The safer workers worked in smaller crews and they also had a more cordial or friendly relationship among themselves. Safer workers also had supervisors who openly showed them respect and gratitude by incorporating or considering their suggestions and by praising them for work well done. The safer workers were those who had positive feelings about their employer. For instance, they felt that they would choose the same department as a place of employment even if other options existed. In fact, the safer workers stated that they would probably work at their present job until retirement. They also felt that the employer cared for their welfare. The work pace was also shown to influence safety performance. Workers who are faced with more frequent job deadlines and who get involved in competition with fellow workers had more injuries, (Hinze and Raboud, 1988).

In a research carried out by Jannadi (1995), impact of human relations on the safety of construction workers, it was found that an effective use of human relations would improve safety programs and make safe behavior a habit for workers. It was also found that safety performance of each worker was very much related to his attitude towards his fellow employees and employer. One more conclusion from the study was that management's attitude towards worker's welfare can also play a major role in developing safe behavior among the workers and thus a safe performance in the workplace. This study showed that competition among workers, fatigue, and working under pressure had a tremendous impact on safety.

Workers who fact deadlines which are almost impossible to meet, compete with other crew members, and work overtime have more injuries. The workers are emotionally vulnerable and preoccupied with their problems since most of them are working in unsecured conditions, (Kartam et al, 2000).

Koehn et al. (1995) concluded in their research about developing countries, workers are generally unskilled or semiskilled, poorly paid, temporarily employed, low productivity rates, and often migrate in a group from one place to another for better job or position

2.5.5 Welfare facilities

The contactor must be provided adequate welfare facilities for his workers usages, prior to starting the construction activities. The contractors must meet the following requirements in order to prevent construction site accidents. (Permana, 2007):

- Smoking area
- First aid facilities
- Food and drinking water
- Toilets
- Ambulance

2.5.6 Administrative and Management Commitment

"Safety is no Accident", "Safety is up to you", "Be Alert -Stay Alive" and "Safety Pays" are few of the common slogans on posters, signs or in magazines whenever men are working in any industry. Frequently, many companies feel that by providing this visual lip service to accident prevention they have viable safety program. Safety must be regarded as a basic component of the management philosophy, just as operating at a profit is, because cost of accidents presents a serious drain of profit. An aggressive company has to examine each of the operations with a keen interest to see not only the work is done in the most efficient manner to ensure greatest potential profit, but also that it is done as safely as possible for the very same reason, (Baig, 2001).

Administrative and management commitment for safety is a very important factor in determining a company's safety performance. Companies which hold their project management accountable for accidents along with productivity, schedules, quality, etc. are the ones which have the best safety records. A critical task in developing a viable safety program is to define management's policy. Most programs fail due to the lack of sincere interest by top management. If top-level management is not genuinely interested in safety procedures, it is most likely that no one else in the company will be. The policy established should contain only what can be supported by intentions and available resources. The safety program goals should be achievable, but demanding and measurable, so that achievements can be monitored and measured, (Bu-Khamsin, 1999).

The term commitment is really directed at management since it is solely management s responsibility to provide a safe and healthy workplace for its employees. When occupational injuries and illnesses occur they are considered to be failings within the management system. With this said management sets the tone for safety and health within the workplace, (Reese, 2003).

One of the important aspects towards enhancing safety culture is through the safety commitment displayed by the top management of the company. Surveys commissioned by the Health and Safety Excusive (HSE) revealed that 75% of all fatal accidents in the civil engineering industries in the United Kingdom are generally caused by ineffective management action taken that large scaled construction companies generally having better safety performance due to the high level of safety support and commitment shown from

the top management. Research found that the reduction in accidents would be achieved when top management takes an active interest and is dedicated to safety enhancement as well as maintaining good safety standards, (Teo et al., 2005). Hence, Support and commitment of top management is not sufficient. They must know what it is that they are committed to. That is, what they must do. These obligations cannot be delegated. Support is not enough: action is required. Top management support without action is nothing (Abdel-Razek, 1998).

Hinze & Raboud (1988) concluded in their research on safety on large building construction projects, that top management must be supportive of safety in order to make safety efforts more effective.
Mattila, et al, (1994) conducted a research to study the connections between good management in general and safety. The study was conducted at 16 sites of a construction company. These sites had 15 site managers and 16 other first-line supervisors. The study proved that the most effective supervisors and managers paid more attention to monitoring worker performance and spent less time indicating antecedents than did their less effective counterparts.

The results of the study pinpoint the safety management's role in occupational safety. It is obvious that the supervisor has the opportunity to influence and control behavior, as well as the methods used, and the quality of the work environment. In short, the study shows that effective supervision also means safety. Both research and practical experience indicate that the role of top management is crucially important for achieving results in safety. Unsafe conditions and accidents are usually a sign that something is wrong in the management system itself, (Kartam et al, 2000).

2.5.7 Safety Inspections

Safety inspections are one means by which project managers and site supervisors can become acquainted with the nature of the safety conditions on-site. Jobsite safety inspections by the forepersons are helpful in terms of reducing work injuries, (Hinze and Gambatese 2003).

The use of safety inspections has been shown to have a positive effect on a company's loss control initiative. In fact companies who perform safety inspections have fewer accidents incidents than companies that do not perform inspections. (Reese, 2003).

Good inspections are worth doing. In 1981 a survey of 143 firms in the USA showed those conducting safety inspections averaged nearly 40 percent fewer accidents than firms without an established inspection program, (Al-Amoudi , 1997).

2.5.8 Safety Meetings

Regular safety meetings are necessary for communicating safety information to all parties. Safety meetings and safety discussion are a practice done by the safety professional, holding a ten-minute weekly meeting for the crew, discussing the hazards in the work they do and the procedures to be followed to prevent injury or property damage (Al-Amoudi, 1997).

A well planned safety meeting is an excellent morale builder. When an employee is convinced that his employer is concerned about his on the job safety, the employee will conform to the safety rules and perform his work in a safe manner (Fang et al,2004)

To make safety meetings more effective, there is a need for more practical and current subject material given by a variety of qualified speakers. They might come from outside, from either the union or the company itself. Smaller meetings for specific crafts also may be appropriate, with more discussion dealing with immediate problems. For crews, which have a variety of work assignments, discussion of the safety aspects of each new assignment might be held before the task, is begun (Ng et al, 2005).

2.5.9 Role of Government and Engineering Societies

The government should play an important role in safety management in the construction industry. This is by enacting specific labor legislation, issuing laws and rules to protect labor, conducting a periodically work sites inspections through a competent safety engineers and subjecting the contractors to a citation or fine for unsafe conditions or hazards existing on a projects. The engineering societies have played an important role in developing and enforcing safety standards. Engineering ethics codes and related educational activities are another way in which the organizations help to eliminate dangerous situation, indirectly, in this case, by contributing to the development of safety consciousness among engineers (Fang et al, 2004).

Obviously, an important objective of engineers is to minimize all types of technological hazards. Engineering societies contribute to the achievement of this goal in several ways: (1) By helping to extend engineering knowledge; (2) by formulating and promulgating safety standards; (3) by making engineers more safety conscious; and (4) by supporting engineers who take strong positions on behalf of worker and public safety, (Fang et al, 2004).

The safety legislation and policies have a great impact upon the safety level of a construction worksite. Legislation forms a framework in which health and safety is regulated and controlled. All project managers have to follow the rules and regulations duly and punishments to be meted out lo those who flout them. Legislation and its enforcement do affect construction safety lo a considerable extent. As such, safety legislation has to be taken seriously when planning job activities and setting up company policies, (Teo et al, 2005).

Labor unions in industrial countries are powerful and can pressure contractors to provide safe working conditions and safety equipment to protect their workforces' rights and health. Hence, workers are not aware of their rights to safe working conditions. In developing countries, labor groups feel alone with no organization to defend them and they have to accept the company's policies and rules, (Kartam et al, 2000).

Koehn et al, (1995) concluded in their research that in developing countries laws to protect laborers may not be strictly enforced. Also, contractors and their employees tend to ignore basic safety rules and regulations. Government regulations for save work conditions that meet safety needs mainly reflect the contractor management thinks.where he deals with of the safety regulations as guidelines to follow to help him develop safety policies and procedures to meet specific needs .

2.5.10 Crane and Lifting Equipment

All contractor crane operators require a valid license in Saudi Arabia. In addition, the cranes shall have valid safety inspection stickers, and manufacture safe working load (SWL) stickers. Before beginning any crane operation, the supervisor and the operator should complete the pre-operation checklist. Also, a lift plan showing the essential carne operation requirements must be included. One competent person must be in charged of the lift with responsibilities of explaining in details, the duties of all involved in the lift before the actual lift commence, (Bu-Khamsin,1999).

2.5.11 Safety Educating and Training

It is widely accepted in the construction industry that training plays an important role in worker safety. Worker training typically begins with worker orientation and continues as workers need to become more informed about certain aspects of the work they are doing. These additional training sessions may include topics such as confined space entry, hot work, traffic control, procedures, and a wide assortment of other topics, whether to introduce new information or merely to provide a refresher on a subject, (Hinze and Gambatese, 2003).

The provision of safety training for employees is one important aspect for consideration to improve safety performance. A study on the effect of first aid training on Australian construction workers concluded that training has a positive preventive effect on workers to avoid injury. It has also been found that workplace injuries would be reduced if workers received first aid training, (Teo et al, 2005).

A formal training program helps personnel to carry out various preventive activities effectively. It also helps establish a positive attitude towards safety and integrates safety into the production and quality goals, (Kartam et al, 2000).

The training providing safety skill and information should be supplemented by the techniques of persuasion. Persuasion has an important function. It is most common form is the poster used to indicate bad habits, pinpoint the advantages of safe working, or give detailed information, advice, or instruction on special points, (Al-Amoudi, (1997). Koehn et al, (1995) concluded in their research that in developing countries, laborers are not trained in safe work practices, and there tends to be a lack of management commitment to safety programs and various safety procedures.

2.5.12 Disposal of Hazardous Materials and Waste

In Saudi Arabia, the contractors are required to dispose off hazarded waste according to Saudi government regulations. In this respect, the contractors must provide proof that the hazardous waste has been properly disposed of a licensed hazardous waste disposal facility. Overall, the contractor must give full attention to the following when dealing with hazardous materials and waste (Bu- Khamsin,1999)**:**

- Hazard identification plan
- Waste management plan
- Disposal site

2.5.13 Personal Protective Equipment (PPE)

Providing appropriate equipment's to avoid the probabilities of accidents to workers, certain things that must be considered and these includes the implementation of PPE which may be uncomfortable to wear or may be an obstruction, strict inspection on proper implementation of PPE; and high cost of providing PPE. There are two categories of PPE. The first must be used safety helmet; safety shoes; and suitable working clothing. In addition, the second category depending kind of work, like eye protection, protective gloves, ear protectors and safety belt (Jannadi, 2001).

2.5.14 Excavation and Trenching

Usually the first job to be done on the site after site surveys and laying out of the site once the contract has been is groundwork for the foundations. In the case of domestic housing, the footings are unlikely to require excavations greater than half a meter and may be dug by hand, (Occupational Safety and Health Administration). For buildings, the foundations may need to be several meters below ground level. This will require the digging of trenches in which work will have to carry out to lay or erect the foundations. Trenches deeper than 1 m are likely to be dug using machines such as excavators. Excavations are also dug to permit lying of cables and pipes. Contractors often use special-purpose excavators capable of digging deep but narrow excavations. If workers have to enter these excavations, the hazards are essentially the same as those encountered in excavations for foundations (Eckenfelder, 1997).

Work in excavations deeper then 1 m needs especially careful planning and supervision. The hazard is the risk of being struck by earth and debris as the ground collapses along the side of the excavation. Ground is notoriously unpredictable; what looks firm can be caused to slip by rain, frost or vibration from other construction activities nearby. What looks like firm, stiff clay dries out and cracks when exposed to the air or will soften and slip after rain. A cubic meter of earth weighs more than 1.8 ton; a worker struck by only a small fall of ground risks broken limbs, crushed internal organs and suffocation. Because of the vital importance to safety of selecting a suitable method of support for the sides of the excavation, before work starts, the ground should be surveyed by a person experienced in safe excavation work to establish the type and condition of the ground, especially the presence of water, (Xie et al, 1999).

2.5.15 Scaffolds

Scaffolds consist of easily assembled frameworks of steel or timber on which working platforms may be placed. Scaffolds may be fixed or mobile. Working platforms on scaffolds consist of good-quality timber boards laid so that they are level and both ends are properly supported; intervening supports will be necessary if the timber is liable to sag due to loading by people or materials, (Yassin, 2004). Platforms should never be less than 600 mm in width if used for access and working or 800 mm if used also for materials.

Where there is a risk of falling more than 2 m, the outer edge and ends of a working platform should be protected by a rigid guard rail, secured to the standards at a height of between 0.91 and 1.15 m above the platform. To prevent materials falling off the platform, a toe board rising at least 150 mm above the platform should be provided along its outer edge, again secured to the standards, (Heng, 2006).

Scaffolders who erect and dismantle scaffolds should be given specific training and experience to ensure their own safety and the safety of others who may use the scaffolds. Scaffolds are often provided by one, perhaps the main, contractor for use by all contractors. In this situation, trades people may modify or displace parts of scaffolds to make their own job easier, without restoring the scaffold afterwards or realizing the hazard they have created. It is important that the arrangements for coordination of health and safety across the site deal effectively with the action of one trade on the safety of another, (Hislop, 1999).

2.5.16 Fire Prevention

Prior to construction stat-up, the contractors must take into account the potential hazards that can be encountered on the construction site by making provisions for the fooling: protection of machinery and equipment, storage of flammable and combustible material, housekeeping, staff training and end-of-shift checks. Each contractor has contractual obligation to provide and maintain adequate, easily accessible fire extinguishers on the job site. There are three types of the extinguishers, which are normally found in construction site: water, carbon dioxide and dry chemical types. Contractors personal should be aware of the fighting equipments available on the site and be familiar with its use, (Hislop, 1999).

2.5.17 Transportation

The contractor must employ only qualified personal a drivers of vehicles and provide them regular refresher driving courses and training . it in a government law that each person driving a vehicle must possess a valid driver's license. It is the responsibilities of the drivers to ensure that his vehicle is safe to operate. In order to prevent serious injuries and fatalities resulting from accidents, the contractor must consider the following, (Hammer, 1985):

- Passenger seating a seat belts
- Vehicle condition

2.5.18 Economic Investment

Economic investment in safety has considerable influence on safety performance. Many projects generate little profit for the companies and in some cases huge losses are incurred. Thus there is often an inadequate economic investment in safety on most projects. Safety is often considered an issue supported by everyone. Unfortunately, when it comes to spending money on safety, many people do not feel it is vital to the success of the project. The main concern of a contractor is how to save money and reduce costs. Safety is usually considered a secondary priority in the company's plans. Safety is considered a waste of money by most contractors since they may be unaware of the effectiveness of safety prevention programs in reducing costs and increasing productivity (Kartam, et al. 2000).

The cost of establishing and administering a construction safety and health program is somewhat less tangible, but can be estimated with reasonable accuracy. Data collected from a significant sample of contractors working at various construction sites in 1980 indicate that the cost of administering a construction safety and health program usually account to about 2.5% of direct labor costs. These costs include salaries for safety, medical and clerical personnel, safety meetings, inspection of tools and equipment, orientation sessions, site inspections, personal protective equipment, health programs such as respirator-fit tests and miscellaneous supplies and equipment,(Improving construction safety performance, 1982).

A popular assumption holds that increased investment in safety produces improved safety performance. Most of the current literature suggests a relationship between safety investment and accident loss. This relationship shows that accident loss will be reduced when investment in safety is increased. Zero investment in safety usually results in maximum accident losses while initial investments have the greatest impact, which results in large decrease in accident losses, (Al-Amoudi1997).

2.5.19 Medical Facilities

Medical facilities include the availability of the medical advice; adequate facilities for first aid treatment and conducting periodically medical testing. Workplace hazards often can be eliminated by redesigning the site. Where it is not feasible to eliminate such hazards, workers must control them to prevent unsafe and un- healthful exposure. Workers must eliminate or control the hazard in a timely manner once it becomes apparent. Specifically, as part of the

program, workers should establish procedures to correct or control present or potential hazards in a timely manner. One of these procedures is establishing a medical program that includes first aid onsite as well as nearby physician and emergency medical care to reduce the risk of any injury or illness that occurs, (OSHA 2202, 2002).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents research procedure and method used in this research to achieve the objectives which have been highlighted in Chapter one. The Research method used here is quantitative.

The methodology adopted for this study is a questionnaire survey. The information or data were gathered using questionnaires covering a wider spectrum of respondents among construction industries in Sudan.

This research work was carried following these steps: review of literature related to safety performance, the information about the research design, research location, pilot study, questionnaire design,, research structure and statistical data analysis.

3.2 RESEARCH DESIGN

The first stage of the research is to identify the aim of the study and to highlight the problems statements. Also establishing of clear objectives is considered within the research plan.

The second stage of the research includes a summary of the comprehensive literature review. Literatures on safety performance were reviewed.

The third stage of the research includes a pilot study which was conducted to the assessment of the factors affecting safety performance in construction sites in Sudan.

The fourth stage focus on the modification of the questionnaire, throughout the feedback obtained from the pilot study. The purpose of the pilot study is to test and prove that the questionnaire contents are clear to be understood by respondents. This will be assisting achieving the objectives of the research. In addition, it is important to ensure that all information received from experts would be useful in achieving the research objectives.

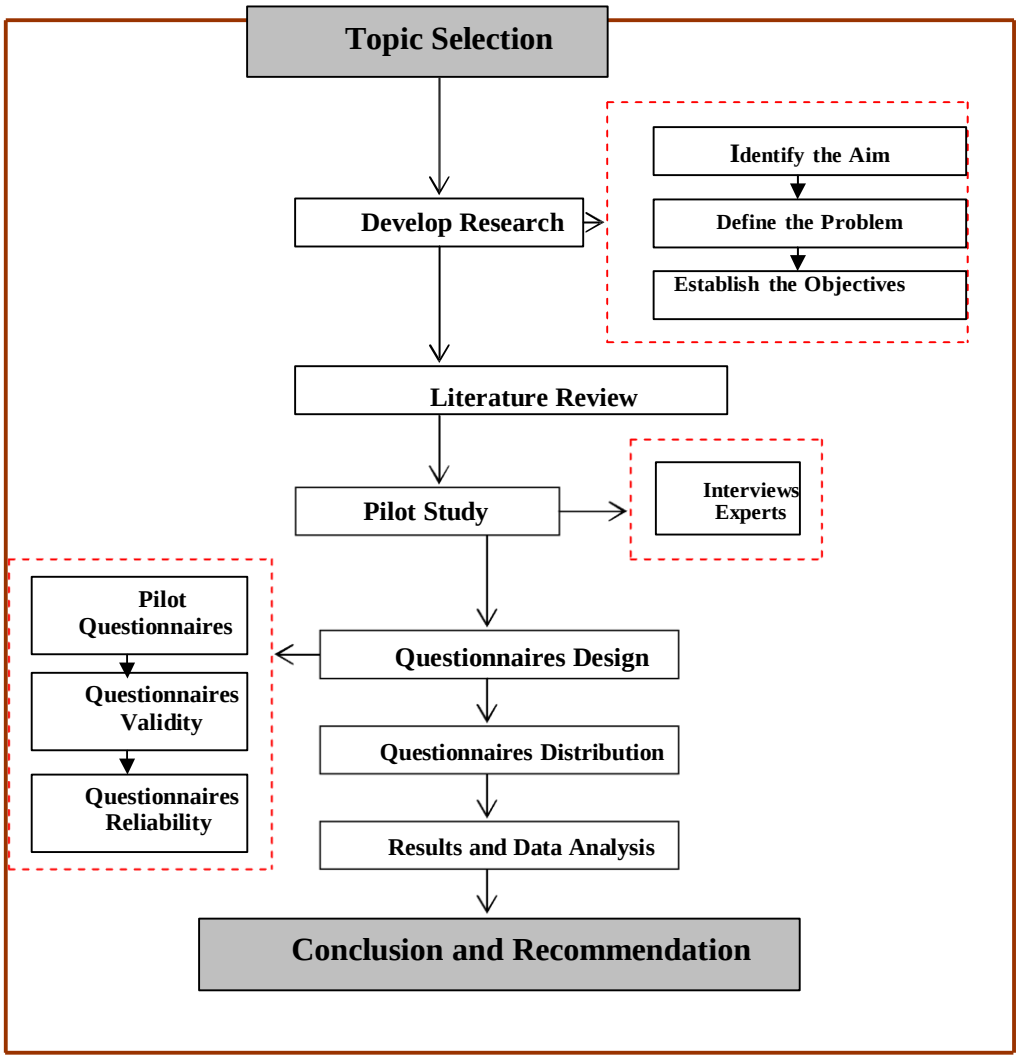


Figure 3-1 Flowchart of Research Methodology

The fifth stage of the research focused on distributing questionnaire. (70) copies were distributed targeting contractors in building, roads and bridges water sewages work, and other work.

The sixth stage of this research is the analysis and discussion of the data obtained from questionnaires. Statistical Package for the Social Sciences, (SPSS) commercially available was used to perform the required analysis. The final phase includes the conclusions and recommendations. Figure 3.1 shows the methodology flowchart.

3.3 RESEARCH LOCATION

This research was conducted in Sudan .The questionnaire were distributed to cover the geographical locations over Khartoum.

3.4 PILOT STUDY

It is customary practice that the survey instrument should be piloted to measure its validity and reliability and test the collected data. The pilot study was conducted by distributing the questionnaire to panels of experts having experience in the same field of the research to get their remarks on the questionnaire.

Three experts contacted to assess the questionnaire validity.

Expert comments and suggestions were collected and evaluated carefully. All the suggested comments and modifications were discussed with the direct supervisor before considering them. Some minor changes, modifications and additions were done to the questions and the final questionnaire version was constructed and used for the study.

3.5 QUESTIONNAIRE DESIGN

According to the review of literature and after interviewing experts who were familiar with the safety performance at different levels, all the information that could help in achieving the study objectives were collected, reviewed and formalized to be suitable for the study survey and after many stages of brain storming, consulting, amending, and reviewing executed by the researcher with the supervisor, a questionnaire was developed with closed and open-ended questions.

The questionnaire was designed in the Arabic language, to be easily understood. An English version was attached in (Appendix A-1). Unnecessary personal data, complex and duplicated questions were avoided. The questionnaire was provided with a covering letter which explained the purpose of the study, the way of responding, the aim of the research and the security of the information in order to encourage high response. The questionnaire design was composed of three parts to accomplish the objectives of the research, as follows :

Part A: General Information of Company and Respondent

This part is related to general information about the companies and respondents**.** The respondents were requested to answer general information pertaining to their classification and experience in construction. This part is used to determine the size, experience of respondents and companies, etc.

Part B: Information of Safety in Company [This part was designed to achieve hypothesis 1]

This part is used to determine safety situation (practice) and perception of the respondents and companies. This part contains nine questions to assess the level of safety practice in the construction company

Part C: Factors Affecting the Safety Performance in Construction Projects [This part was designed to achieve hypothesis 2 +hypothesis3]

This part includes the list of the factors affecting the safety performance in the construction industry. It contains eighteen groups and seventy-two factors represented in table 2-3 above. For each factor there is a question, for measuring the degree of impact on safety performance in construction project.

Respondents will be invited to state any other factors that affect safety performance and to rate these factors. The degree of impact is based on a five-point Likert scale. These five points are (very high), (high), (moderate), (low), and (very low).

Factors Affecting the Safety Performance in Construction Projects

Level	Very High	High	Moderate	Low	Very Low
Scale	1	2	3	4	5

To determine the relative ranking of the factors, these scores were then transformed to importance indices based on the formula .

Formula Relative Importance Index = $\frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$

Where W is the weighting given to each factor by the respondent, ranging from 1 to 5, ($n1$ = number of respondents for very high , $n2$ = number of respondents for high , $n3$ = number of respondents for moderate, $n4$ = number of respondents for low , n5 = number of respondents for very low). A is the highest weight (i.e. 1 in the study) and N is the total number of samples. The relative importance index ranges from 0 to1.

Thus, the questions are in a standardized format and sequence. This guarantees that each question is asked the same way for each respondent, simple to administer and relatively easy to analyze and compile. The questionnaire was translated into Arabic to make it easy and clear.

3.6 STATISTISAL MANIPULATION

To achieve the research goal, research used the statistical package for the social science (SPSS) commercially available for manipulating and analyzing the data. The analyzed data include the description analysis includes (frequencies, means, standard deviation).

CHAPTER 4

ANALYSIS AND RESULTS DISCUSSIONS

4.1 INTRODUCTION

This chapter presents and discusses the analyses and results of the collected data. The chapter includes a description of respondents, the classification, experience, size and the safety situation of the respondents and respondent companies. It also, includes the ranking of the factors affecting the safety performance in construction by using relative importance index. However, before discussing the data analyses and results, the characteristics of construction contractors who participated in the survey are introduced.

4.2 DESCRIPTION OF THE RESPONDENTS

This section presents the description of the respondents who participated in this study. The results obtained from the questionnaire shows that, Many the companies worked in the construction industry participated in the study located in Sudan. The following section will describe the characteristics of the respondents that participated in this survey. These characteristics also include the companies categories, experience and size of the companies.

4.2.1 Job Title of Respondents

results of questionnaire showed that, 25 % from the sample was project managers,23 % from the sample was site engineer, 15 % health and safety executive (HSE) engineer and 37% from the other title. This means the ratio of health and safety executive (HSE) engineer is weak we need more awareness for companies about important of this position in works. Figure 4-1 shows the distribution of each type of respondent.

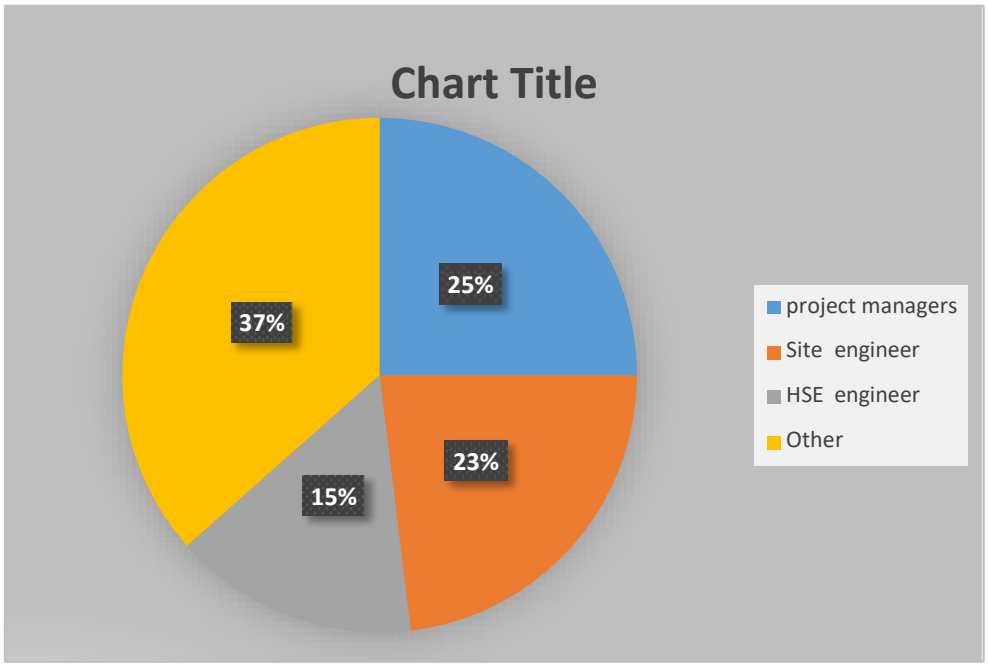
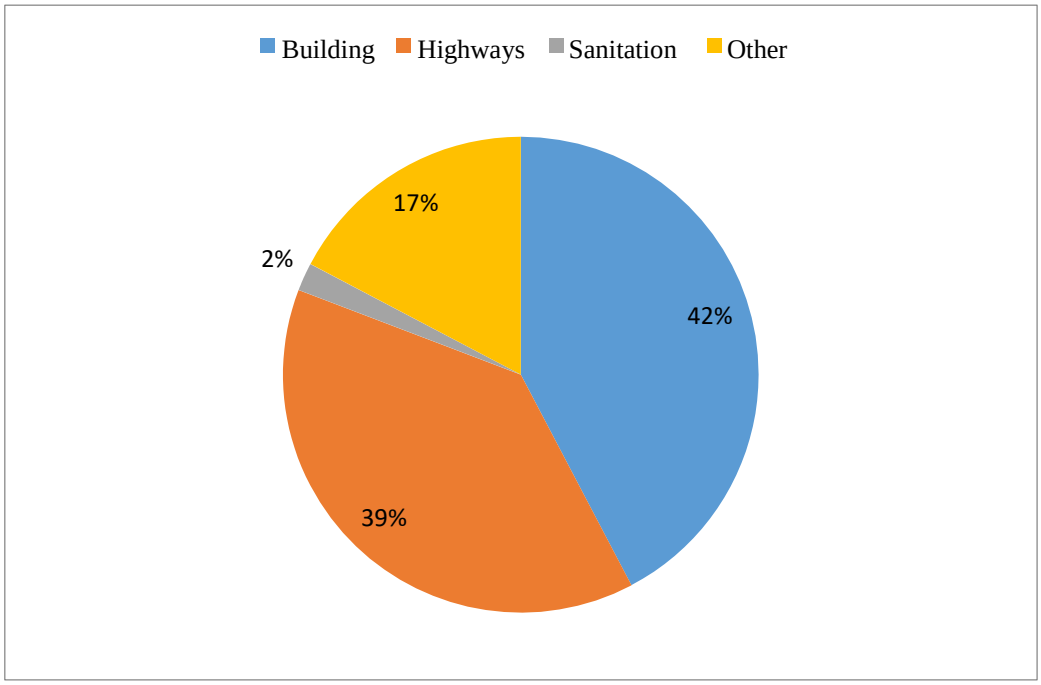


Figure 4-1: Job Tile of Respondent

4.2.2 Classification of Construction Companies

	Frequency	Percent
Building	22	42
Highways	20	39
Sanitation	1	2
Other	9	17
Total	52	100.0



From the table and figure 4-2 above, it is noticed clear that the majority of the sample had a specialization in Construction is building at a rate of 42% and then who was the specialization of roads and bridges at a rate of 39% and then who their specialization sewage accounted for 17% of the total sample researched and then who their specialization for other work accounted for 2 % of the total of sample researched. this mean the most companies of respondent's specialization in building and roads & bridge works .

4.2.3 Working Experience for Company

Working experience is measured in the number of years a company has been operating in the construction industry. The majority of the surveyed companies "82.7%" have been practicing the construction business for more than 5 years; it was sum of (21.2, 17.3, and 44.2). Figure 4-3 shows the working experience of Companies in the construction field.

	Frequency	Percent
less than 5 Years	9	18
5 to 10 years	11	21
Over10 to 15 years	9	17
Over 15 years	23	44
Total	52	100.0

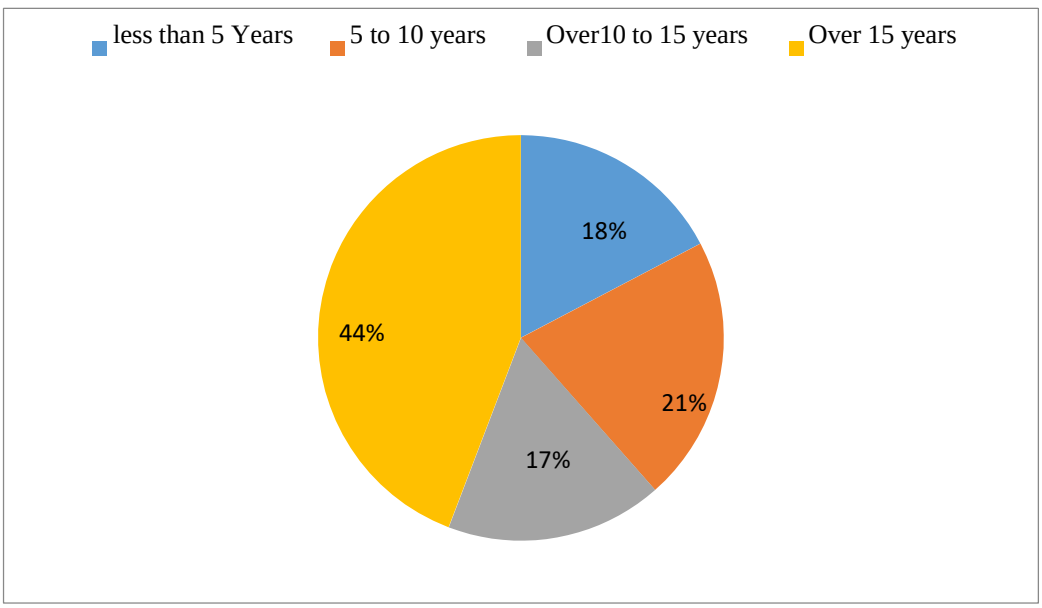


Figure 4-3: Working Experience for Company

4.2.4 Working Experience for Respondent

The years of experience vary from less than 5 years to more than 15 years. 34.6% from the sample have less than 5 years' experience in the construction field, and 65.4% from the sample have over 5 years' experience in the construction field. The most respondent have experience over 5 years that is means have good practice in the construction field. Figure 4-4 shows the working experience of respondents in the construction field.

	Frequency	Percen
Less than 5 years	18	35
5 to 10 years	16	31
Over10 to 15 years	10	19
Over 15 years	8	15
Total	52	100.

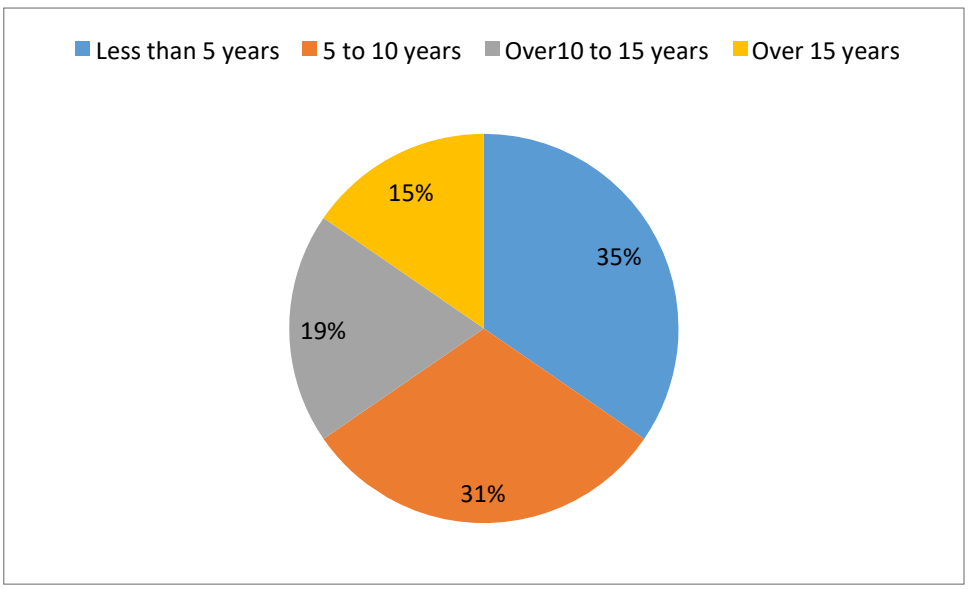


Figure 4-4 Worker Experience in the Construction Field

4.2.5 Respondent Age

Figure 4-5 shows that the 5.8% of respondents are of the age between 15 years to 24 years old and 75% are of the age between 25 years to 44 years old. This is the appropriate age for a graduate engineer to work and start professional life. 19.2% is more than 45 years old, this age for professional engineer.

	Frequency	Percent
15 to 24 years	3	6
Over 24 to 34 years	28	54
Over 34 to 44 years	11	21
Over 45 years	10	19
Total	52	100.0

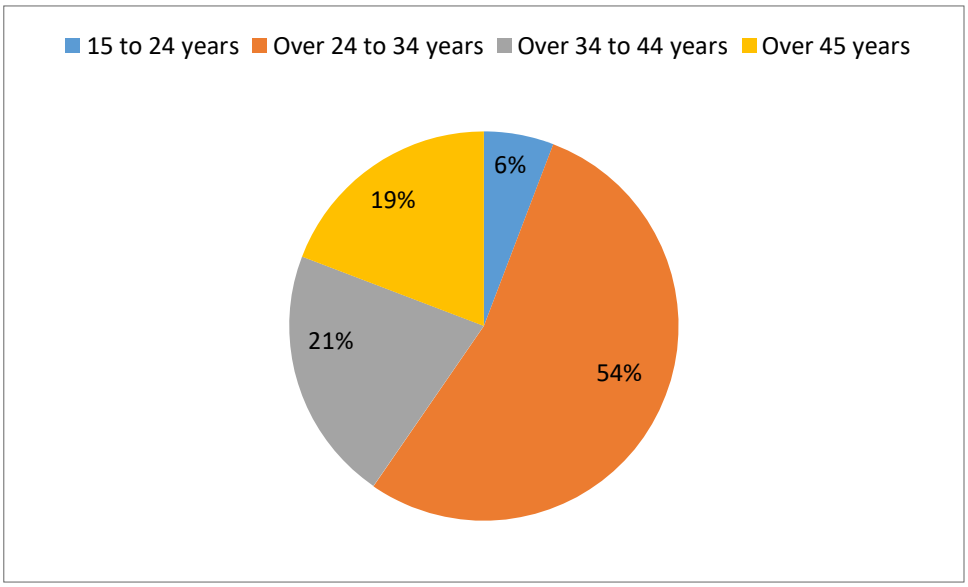


Figure 4-5 Respondent Age

4.2.6 Qualification of Respondent

Figure 4-6 shows that the 5.8% of respondents have Diploma degree and 51.9% have BSc degree, 13.7 % have Master degree and 3.8% have other degree. it is understood that this situation is natural because most of respondents are young (their ages range between 24 to 34).

	Frequency	Percent
Diploma	3	6
B.Sc.	27	52
Master	20	38
Other	2	4
Total	52	100.0

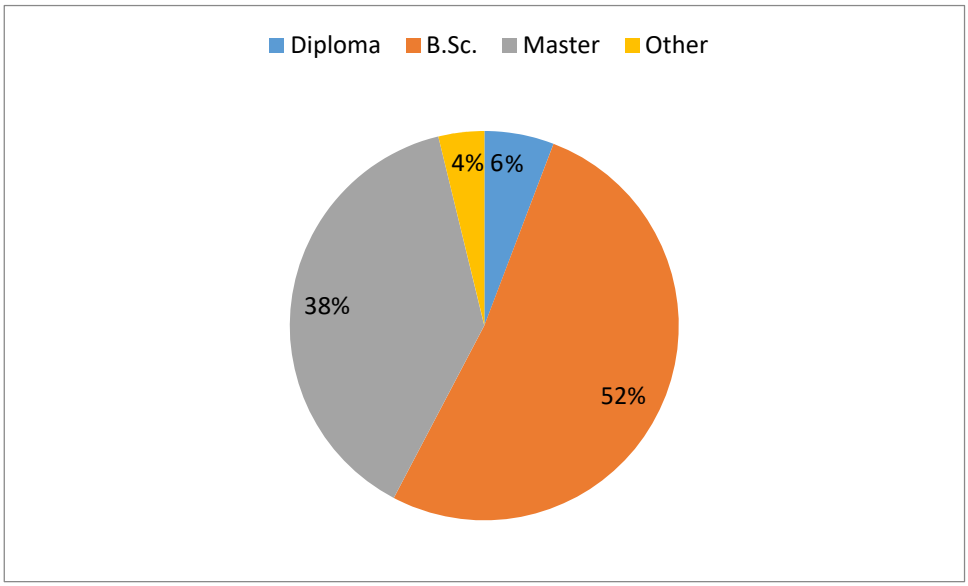


Figure 4-6 Qualification of Respondent

4.2.7 Company Size

Company size is influential in the number of workers. The companies that have less than 50 workers represent 25% of the total participated companies and that which have more than 50 to 200 employees represent 36.5 %. and that which have more than 200 employees represent 38.5 %. This means more than half of the companies have more than 100 workers. Figure 4-7 shows the size of company in terms of Number of workers.

	Frequency	Percent
less than 50	13	25.0
50 to 100	7	14.0
Over 100 to 200	12	23.0
Over 200	20	38.0
Total	52	100.0

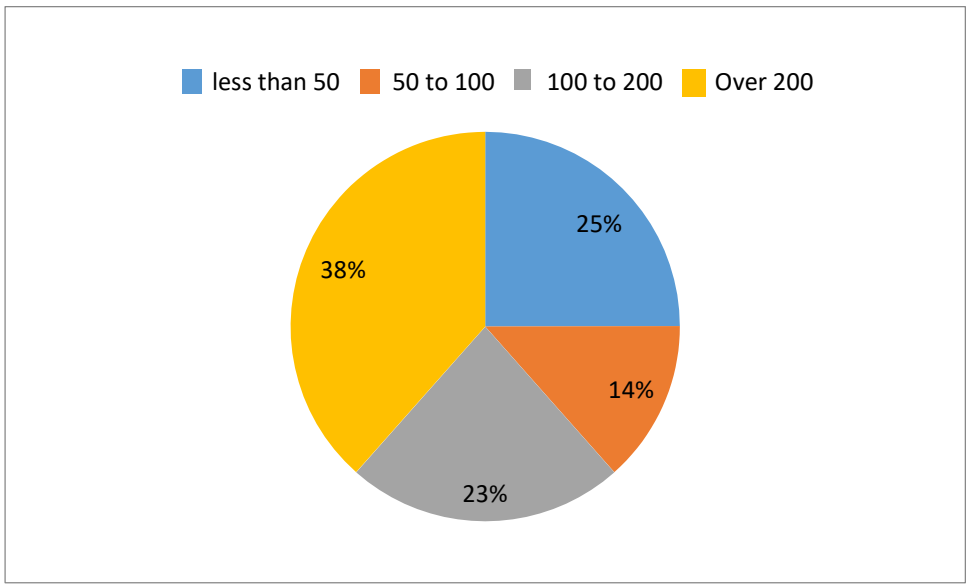


Figure 4-7 Company Size

4.3 RESPONDENTS SAFETY PRACTICE AND PERCEPTION

In this section, the results were concerning respondent's safety practice and perception. The respondents were requested to give information about their perception towards safety.

4.3.1 Availability of Safety Professional

The respondents were asked if their companies have a safety professional. 48.1% of the respondents do not have a safety professional while the remaining 51.9% has. The result relevant that, the companies are not understanding the importance of the safety professional The results of the questionnaire are presented in Figure 4-8.

	Frequency	Percent
Yes	27	52
NO	25	48
Total	52	100.0

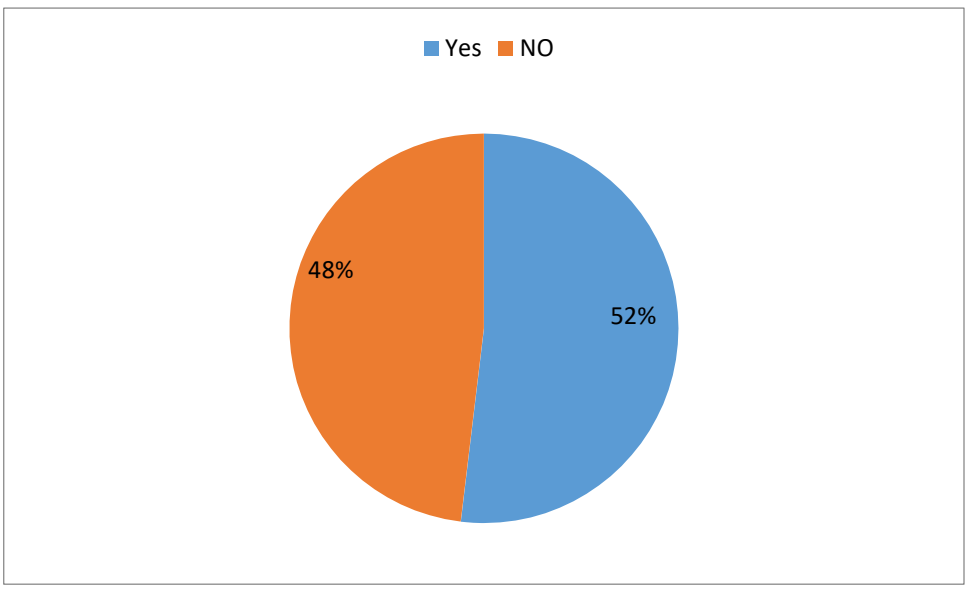


Figure 4-8 Availability of Safety Professional

4.3.2 Availability of Safety Department

The respondents were asked if their companies have a safety department. 53.8% of the respondents did not have a safety department while the remaining 46.2% had. The result relevant that, the companies are not understanding the importance of the safety department.

The results of the questionnaire are presented in Figure 4-9.

	Frequency	Percent
Yes	24	46
NO	28	54
Total	52	100.0

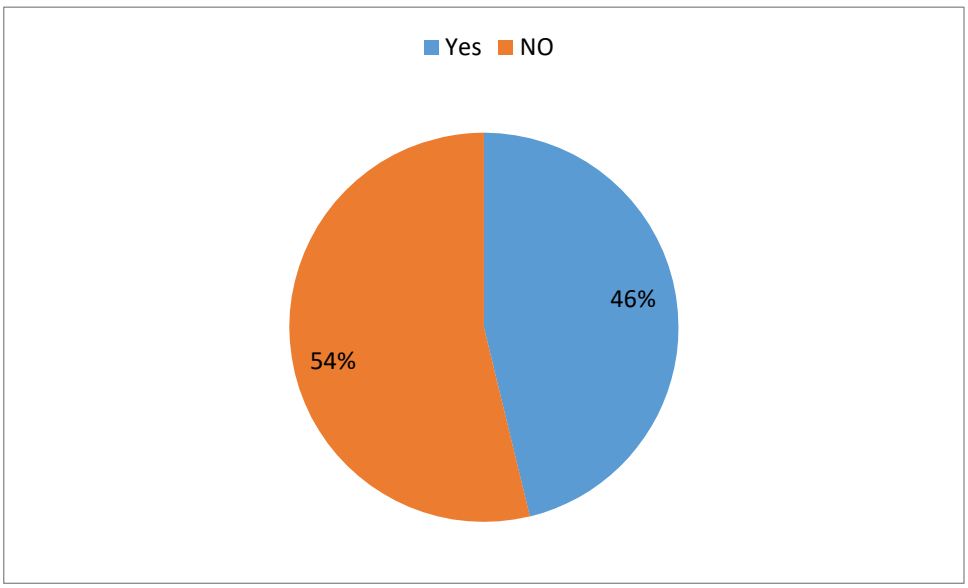


Figure 4-9 Availability of Safety Department

4.3.3 Using of Safety Program or Manual

The respondents were asked if their companies use a safety program or manual. About 30.8 % of the respondents are using a safety program or manual. The respondents, which are partially using a program, represented about 53.8%. The remaining 15.4% of respondents are not using a safety program at all. it is understood that this situation is natural because more than half of companies in Sudan have not Safety professional or Safety department. The results of the questionnaire are presented in Figure 4-10.

	Frequency	Percent
Yes	16	31
Partially	28	54
No	8	15
Total	52	100.0

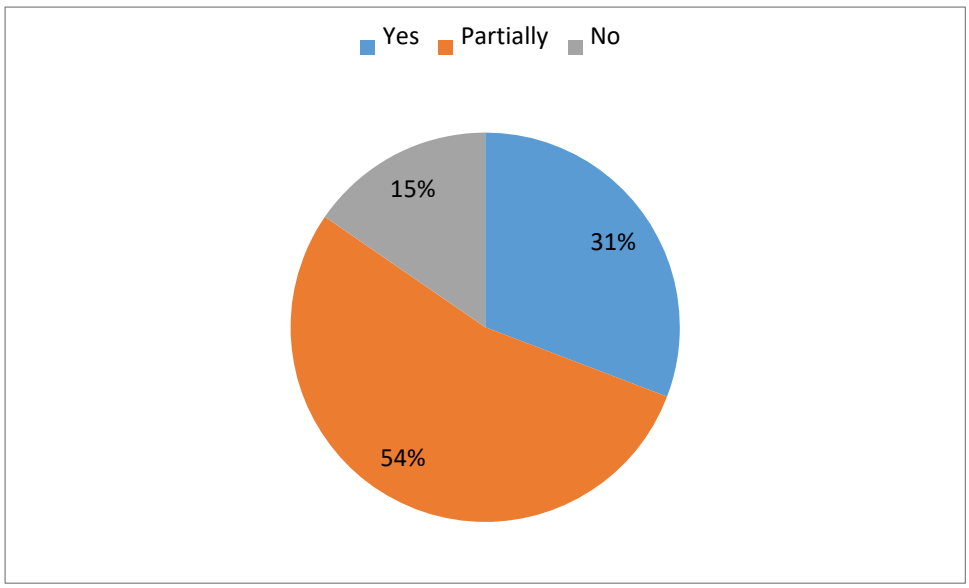


Figure 4-10 Using of Safety Program or Manual

4.3.4 Safety Knowledge

The respondents were asked if they have knowledge about the safety conditions, specifications and provisions. About 50 % of the respondents agreed that they have knowledge of safety. While 46.2 % of the respondents agreed that they have partially knowledge of safety. Only 3.8% of respondents think that they did not have sufficient Knowledge of safety. this means the most of respondents have knowledge about safety or partially. The results of the questionnaire are presented in Figure 4-11.

	Frequency	Percent
Yes	26	50.0
Partially	24	46
No	2	4
Total	52	100.0

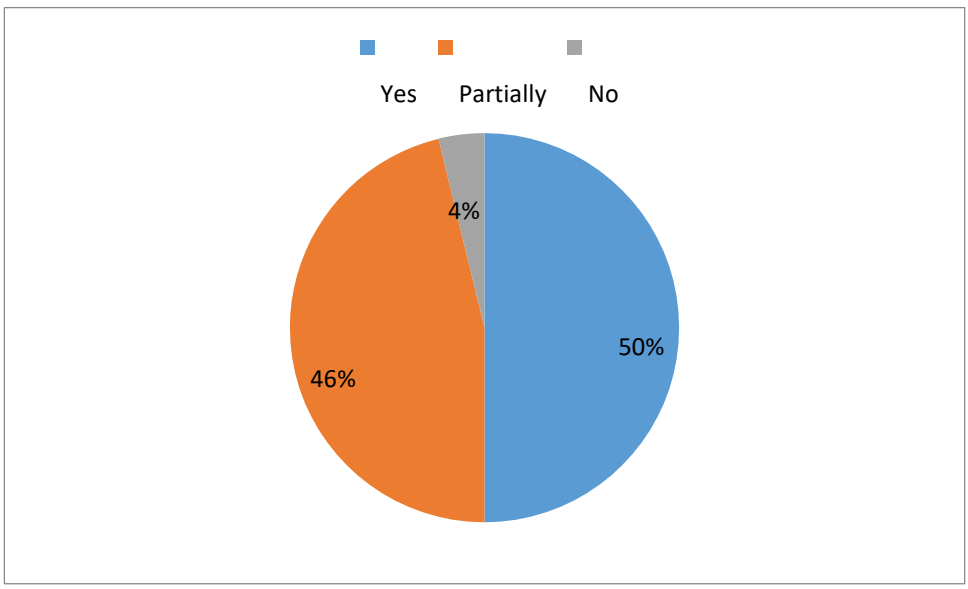


Figure 4-11 Safety Knowledge

4.3.5 Responsibility of Safety Lacking

The respondents were asked about their opinion on responsibility of lacking safety during the construction on site. The parties that have the main responsibility for lacking of safety on site according to the respondents are Engineer (about 23.1%), Safety engineer (17.3%) and the management (46.2%). About 11.5% of the respondents have the view that the worker is responsible for lacking of safety on site.

Only 1.9 % from the sample agreed that the responsible for lacking of safety during construction on "Others". that is means the respondents thinks the top management is first responsibility of safety lacking. The results of the questionnaire presented in Table 4-1.

Table 4-1 Responsibility of Safety Lacking

Responsibility of Safety Lacking	Frequency	Percent %	Rank
Top Management	24	46.2	1
Site Engineer	12	23.1	2
Safety Engineer	9	17.3	3
Worker	6	11.5	4
Others	1	1.9	5
Civil defense	0	0	6
Total	**52**	**100.00**	

4.3.6 Financial Saving

The respondents were asked if they expect any financial saving by complying with safety provisions. About 57.7% of the respondents agreed that there are savings. Nearly 28.8% think that sometimes there are savings. Only 1% of the respondents disagreed that there are financial saving by complying with safety provisions. this means more than half of respondents agreed there are financial saving by complying with safety provisions. The results of the questionnaire are presented in Figure 4-12.

	Frequency	Percent
Yes	30	58
Sometimes	15	29
No	7	13
Total	52	100.0

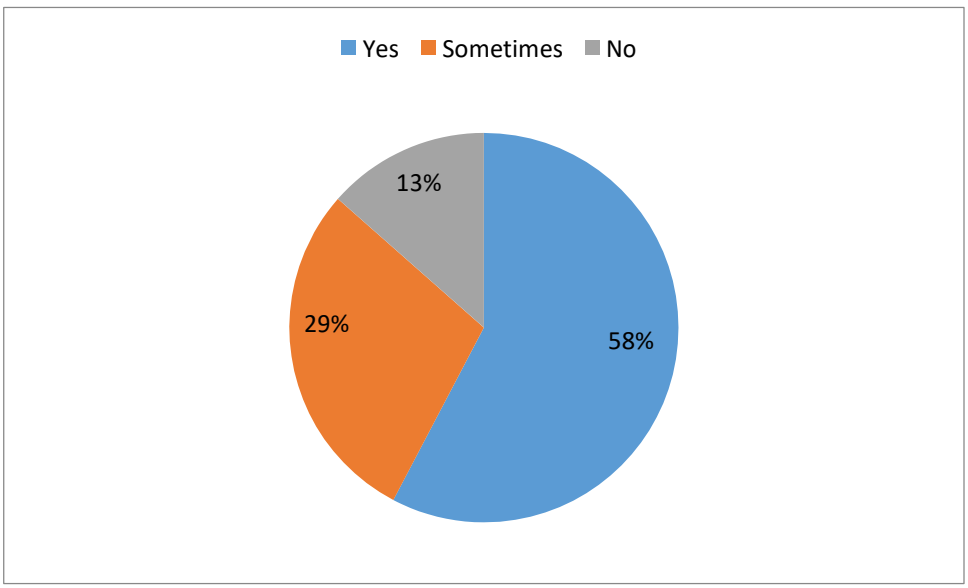


Figure 4-12 Financial Saving

4.3.7 Impact of Accidents

From Table 4-2, it can be observed that, the highest impact of the accident at the project is shown in the financial direction. The respondent have a strong satisfaction that the accidents will cause project cost increasing. This was ranked in the first position with RII of (0.334).

Table 4-2: Impact of Accidents

Impact of Accidents	Percentage of Occurrence					Mean	RII	Rank
	Very High	High	Moderate	Low	Very Low			
Increase on cost	46.2	42.3	9.6	1.9	0.0	1.67	0.334	1
Impairing reputation of companies	46.2	36.5	5.8	9.6	1.9	1.85	0.370	3
Imposing psychological burden on workers	48.1	40.4	7.7	3.8	0.0	1.67	0.334	2
Interrupting project's schedule	34.6	40.4	5.8	19.2	0.0	2.10	0.420	4

"Impairing reputation of companies" was ranked the harmful impact of the accident rate at the company's reputation. The respondent's agreed that more accidents in the project will reflect unstable construction projects, which give warring impales at the project success. This impact at the accident rates at the company's reputation was ranked in the second position with RII of (0.370).

The results reflect also, that, occurrence of rates in construction may influence the schedule arrangement to complete the projects. "Interrupting project's schedule" was ranked in a low influence position at the construction projects with RII of (0.420).

The overall results show clearly that the highest harmful impact from contractor's point of view is traced towards the financial direction, which turn influence other areas. In general, such accidents in construction projects will have negative impact at the sustainability of the project.

4.3.8 Number of disabling injuries

The total number of disabling injuries during last work year from less than 5 is 73%, from 5 to 10 is 19%, over 10 to 15 is 6% and over 15 is 2%. This results means we need more awareness about important of safety for the companies. The results of the questionnaire are presented in Figure 4-13.

	Frequency	Percent
Less than 5	38	73
5 to 10	10	19
Over10 to 15	3	6
Over 15	1	2
Total	52	100.0

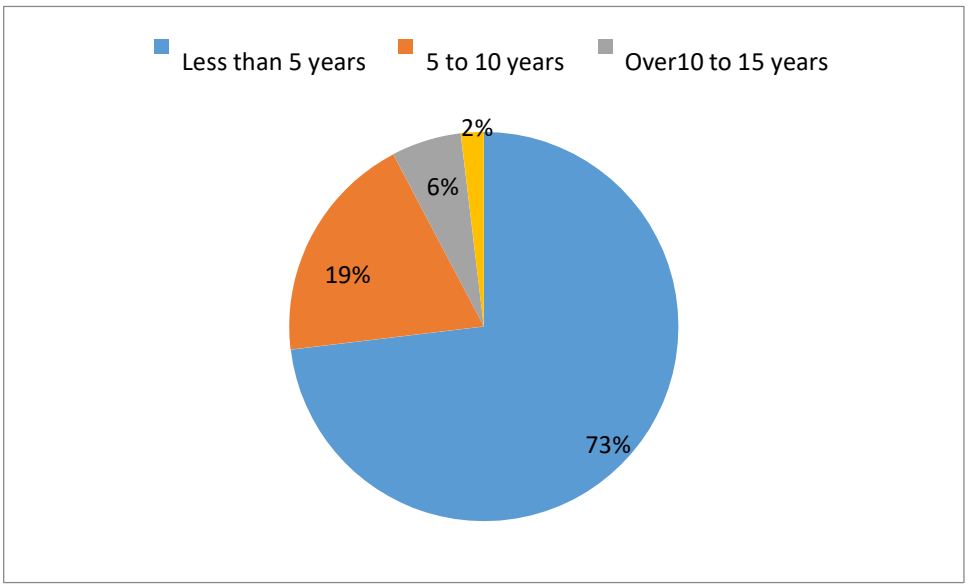


Figure 4-13 Number of disabling injuries

4.3.9 Number of workers

Total number of workers last work year less than 50 is 40%, from 50 to 100 is 14%, from 100 to 200 is 23%, and over 200 is 23%. This results mean the less number of workers decrease the number of disabling injuries in the work.The results of the questionnaire are presented in Figure 4-14.

	Frequency	Percent
less than 50	21	40.4
50 to 100	7	13.5
100 to 200	12	23.1
Over 200	12	23.1
Total	52	100.0

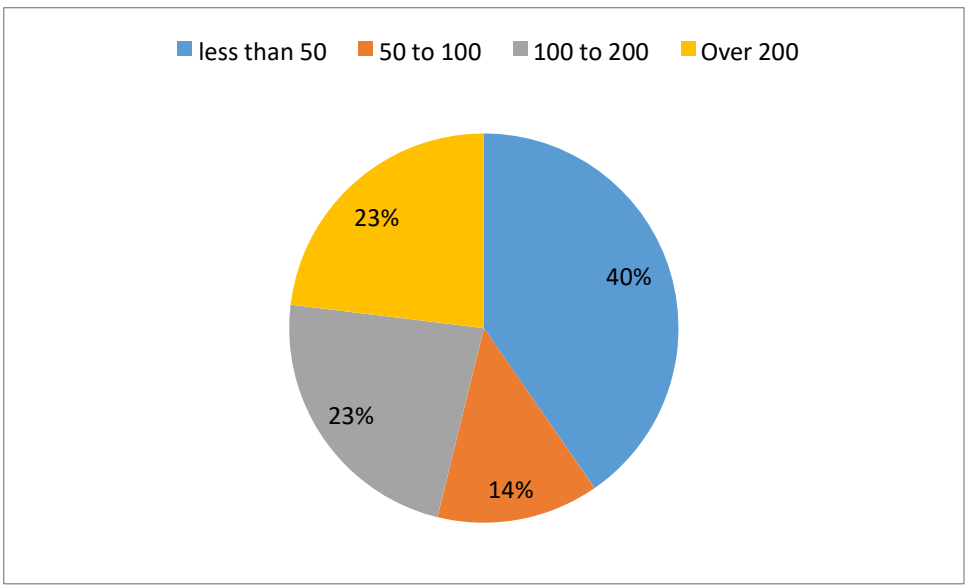


Figure 4-14 Number of worker

4.4 EVALUATION OF FACTORS AFFECTING THE SAFETY PERFORMANCE

Part (C) of the questionnaire includes the list of factors affecting safety performance in the construction industry. It contains seventy-two factors into eighteen groups. the groups were project nature; emergency planning and preparations; signs, signals and barricades; historic, human and psychological climate; welfare facilities; administrative and management commitment; safety inspections; safety meetings; role of government and engineering societies; crane and lifting equipment; safety educating and training; disposal of hazardous materials and waste; personal protective equipment; excavation, trenching, and shorting; fire prevention; transportation; economic investment; and medical facilities. The following sections discuss and interpret of each factor's groups.

4.4.1 Group 1: Project Nature

Table 4-3 shows the respondents opinion about this group affecting the safety performance in construction site according to RII from low to high.

The group contains seven factors and was ranked in the position 5th respect to overall groups with a total RII (0.415). Scope of the project" was ranked in the first position within this group with RII (0.342), and was in seconded. Position to overall groups. This reflects that contractors satisfy that the types of projects (building, roads and water sewage) influence the safety performance conditions in the construction industry.

“" Lighting the site during night working hours “was ranked in the seconded position with RII (0.358) within the project nature group, and ranked in the 5th position respect to overall groups. This result reflects that, the contractors satisfied that the lighting condition during the night is critical to safety conditions. This could integrate specially in the infrastructure.

" Arrangement and organization the site " was ranked in the 3rd position with RII (0.396) within the project nature group, and ranked in the 14th position respect to overall groups. This result reflects that, the contractors satisfied that the arrangement and organization the site is critical to safety condition.

Table 4-3 RII and Rank of Project Nature's Group Affecting Safety Performance

Project Nature Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Lighting the site during night working hours	48.1	32.7	15.4	0.0	3.8	1.79	0.358	2	5
Arrangement and organization the site (site environment)	46.2	21.2	23.1	7.7	1.9	1.98	0.396	3	14
scope of the project	44.2	44.2	7.7	3.8	0.0	1.71	0.342	1	2
Cost of the project	28.8	44.2	26.9	0.0	0.0	1.98	0.396	4	14
Application of new technology in construction projects	28.8	40.4	15.4	9.6	5.8	2.23	0.446	5	39
Planning and scheduling of the project	25	30.8	28.8	15.4	0.0	2.35	0.470	6	56
Clear and easy of project’s design	17.3	40.4	21.2	17.3	3.8	2.50	0.500	7	62
Total						**1.82**	**0.415**		

Within this group, the results relevant that, the contractors are satisfying the importance of " Planning and scheduling of the project "and "Clear and easy of project's design "to improve the safety performance, these factors were ranked in the last two position within this group with relative important index (0.470) and (0.500) respectively. Although the factor " Application of new technology in construction projects "was shown as an important factor for the safety performance from the contractor's perspective in the Sudan with relative important index (0.446)

4.4.2 Group 2: Emergency Planning and Preparations

From Table 4-4, This group contains two factors and was ranked with in 7th position respect to main factors. Within this group, two factors investigated to read this effect on the safety performance. The results show that the factor of, "Develop a plan to respond to emergencies" was ranked in the first position among project nature group with RII (0.418), and ranked in the 21 position among all groups. This indicates that this factor has moderate effect on safety performance.

Table 4-4 RII and Rank of Emergency Planning and Preparations Group Affecting Safety Performance

Emergency Planning and Preparations Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Develop a plan to respond to emergencies	40.4	25	21.2	11.5	1.9	2.09	0.418	1	21
Training workers to respond to emergencies through the exercises	38.5	28.8	15.4	9.6	7.7	2.19	0.438	2	33
Total						**2.14**	**0.428**		

"Training workers to respond to emergencies through the exercises" was ranked in the second position within this group of factors and with RII of (0.438) and in the 33 position respect to overall groups. These results reflect that, the contractors have the willingness and the readiness to improve the awareness level of their labor about safety conditions.

4.4.3 Group3:Signs,Symbol and Barricades

This group contains five factors and was ranked in the second position overall groups, which was revealed the importance of this group respect to safety performance. Table 4-5 shows the results.

Table 4-5 RII and Rank of Signals, Symbol and Barricades Group Affecting Safety Performance

Signs, Signals and Barricades Factors	Percentage of Occurrence					Mean	RII	Rank within this	Rank within
	Very High	High	Moderate	Low	Very Low				
The use of danger signs	40.4	40.4	15.4	3.8	0.0	1.83	0.366	3	7
The use of caution signs	44.2	40.4	11.5	3.8	0.0	1.75	0.350	1	3
The use of instruction signs	38.5	34.6	13.5	9.6	3.6	2.06	0.412	4	17
The use of barricades to close the site for the pedestrians	50	28.8	17.3	3.8	0.0	1.75	0.350	2	3
The use of traffic signals in the site	26.9	32.7	26.9	7.7	5.8	2.33	0.466	5	53
Total						**1.94**	**0.389**		

From this group of factors, it can be observed that," Using of caution signs" was ranked in the first position within this group with a RII of (0.350). The factor was ranked in the 3rd position for overall groups. Such sign takes a yellow color, which reflect a warning safety conditions. The results reflect that the contractors are satisfied that such signs are critical to reduce the accidents rate in the construction site. In addition, the results reflect for easiness that such signs to improve the safety conditions in the site. The results reflect also the importance of these signs for the labors survivals.

“The use of barricades to close the site for pedestrians" was ranked in the seconded position within this group with RII equal to (0.350) and being in the 3rd position with overall groups.

"The use of danger signs" was ranked in the third position within this group of factors with a RII of (0.366). In addition, it was ranked in the 7 position overall groups. This result reveled that “Use of danger signs “which indicate the red-color, that used in the onstruction projects has critical influence at the safety performance conditions. Such signs could protect and guide the labors to take care of the surrounding conditions which inurn protect the labor's life.

The result shows the direct relation between the safety sign with its effect at the safety performance, where the most influence were the danger signs then, the of barricades to close the site for pedestrians and aution signs. "The use of traffic signals in the site” was ranked in the 5 position within this group and in the 53 within overall groups with RII equal to (0.466). This reflects that contractors satisfied he important of the use of traffic signals in the site .

4.4.4 Group 4: Historic, Human and Psychological Climate

From table 4-6, this group contain thirteen factors and was ranked in the 11 position among all other groups (18 Groups) with RII (0.446). Within this group of factors, " worker experience "was ranked in the first position with RII of (0.380) and ranked in the 12 position within overall groups of factors. The rank for such factor could reflect the importance of this factor from the contractor's perspectives. The results indicate that the worker who have a good experience in the field of work such as (building, roads and water sewage) will be familiar with this environment which means that his previous experience will help in better safety y circumstances.

" Relation between the supervisor and workers on the site " was ranked in the 2ndposition within this group with RII of (0.412) and was ranked in the 17 position respect to overall groups. The result indicates that the contractors satisfy the important of relation between the supervisor and workers on the site.

"Interrelation between the workers in the site" was ranked in the 3rd position within this group with RII of (0.424) and was ranked in the 22 position respect to overall groups.

" Decrease work pressure on workers " and " Worker culture background " were ranked in the last two positions with RII in of (0.476) and (0.504) respectively. These two factors also ranked in the position 59 and 64 respectively; respect to overall all groups of factors. This indicates that this factor has moderate effect on safety performance.

Table 4-6: RII and Rank of Historic, Human and Psychological Climate Group Affecting SafetyPerformance

Historic, Human and Psychological Climate	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Non-Excessive overtime work on worker	28.8	38.5	25	3.8	3.8	2.15	0.430	6	28
Worker experience	32.7	46.2	19.2	1.9	0.0	1.90	0.380	1	12
Decrease work pressure on workers	15.4	48.1	21.2	13.5	1.9	2.38	0.476	12	59
Worker safety awareness, knowledge & involvement	40.4	25	21.2	9.6	3.8	2.12	0.424	4	22
Worker accident's experience	19.2	42.3	28.8	3.8	5.8	2.35	0.470	10	56
Worker age	23.1	38.5	28.8	7.7	1.9	2.27	0.454	7	43
Worker safety training received	26.9	38.5	17.3	9.6	7.7	2.33	0.466	9	53
Worker education	21.2	40.4	25	9.6	3.8	2.35	0.470	11	56
Relation between the supervisor and workers in the site	26.9	46.2	21.2	5.8	0.0	2.06	0.412	2	17
Worker culture background	17.3	34.6	30.8	13.5	3.8	2.52	0.504	13	64
Interrelation between the workers in the site	25	44.2	25	5.8	0.0	2.12	0.424	3	22
A worker's ability to communicate with others	23.1	34.6	30.8	11.5	0.0	2.31	0.462	8	50
Relation between the management and workers in the site	28.8	38.5	25	7.7	0.0	2.12	0.424	5	22
Total						**2.23**	**0.446**		

4.4.5 Group 5: Welfare Facilities

From Table 4-7, this group contains five factors and was ranked in the 18 position respect to other remaining groups (overall groups 18) and with RII (0.544). The results show that the contractors are satisfied that (Provision of adequate facilities for first aid treatment) is a critical and important factor that affecting safety performance in the construction projects. This factor was ranked in the 1st position within this group of factors with RII (0.430) and being in the 28 position among overall groups. The result reveal to the fact that, the first aid is the first line defense in case of anybody accidental (injuring) in the site. So the existence of these kits is critical for safety performance. “Provision of food and drinking water" ranked in the second position within this group. with a RII of (0.446) and ranked in the 39 position respect to overall groups. This indicates that this factor has moderate effect on safety performance.

Table 4-7 RII and Rank of Welfare Facilities Group Affecting Safety Performance

Welfare Facilities Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Provision of adequate facilities for first aid treatment	36.5	28.8	19.2	13.5	1.9	2.15	0.430	1	28
Provision of food and drinking water	30.8	38.5	13.5	11.5	5.8	2.23	0.446	2	39
Provision of adequate toilets	19.6	37.3	23.5	7.8	11.8	2.55	0.510	3	67
Provision of an ambulance in the site	26.9	21.2	19.2	9.6	23.1	2.81	0.562	4	71
Provision of special places for smoking	17.3	21.2	9.6	19.2	30.8	3.87	0.774	5	72
Total						**2.72**	**0.544**		

The result illustrated that; the respondents are satisfied that the "Provision adequate toilets" will affect the safety performance. The respondents ranked this factor in the 3rd position within this group but with RII of (0.510). In addition, the factor ranked in the position 67 respect to overall factors. This indicates that this factor has moderate effect on safety performance. These results will be useful to be highlighted for the decision makers and stakeholders within the construction industry to exert more efforts to enhance the labors condition during working hours.

The results revealed that, "Provision of special places for smoking" is not crucial factor to attain safety performance. The results could be matched with the fact that, the construction work deserve a comprehensive attention and careful. This fact is shown clearly from the respondents output as they ranked this factor in the position 72 with a RII of (0.774).

4.4.6 Group 6:Administrative and Management Commitment

This group contains six factors and was ranked in the 4 position respect to other remaining groups (overall 18 groups) with a RII of (0.412). Table 4-8 shows the administrative and management commitment factors affecting safety performance in construction projects.

Table 4-8: RII and Rank of Administrative and Management Commitment Group Affecting Safety Performan

Administrative and Management Commitment Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Safety awareness of project managers	42.3	32.7	21.2	3.8	0.0	1.87	0.374	2	11
Safety awareness of company's top management	46.2	26.9	25	1.9	0.0	1.83	0.366	1	7
Management's attitude towards worker's welfare	36.5	25	26.9	5.8	5.8	2.19	0.438	4	33
Availability a clear company safety policy	46.2	23.1	17.3	9.6	3.8	2.02	0.404	3	16
Issuing & implementation of in-house safety rules, safety program or manuals including emergency plan & procedures	38.5	21.2	21.2	15.4	3.8	2.25	0.450	6	41
Conduction of safety policy review	34.6	34.6	13.5	11.5	5.8	2.19	0.438	5	33
Total						**2.06**	**0.412**		

Within this group, "Safety awareness of company's top management" was ranked in the first position with a RII of (0.366) and was ranked in the 7 position among overall factor's groups.

"Safety awareness of project managers" was also ranked in a top position (2nd position) with a RII of (0.374). This factor was ranked in the 1st position with Tam et al. (2004) and with a RII of (0.93). This could be returned to the following:

1. The project manager has direct responsibilities for the safety performance condition in the site.
2. The project manager is responsible to carry out the safety clauses as mentioned in the contract conditions.
3. The project manager has ethical responsibilities to advise and edify the labors about the safety consideration during the working hours.

"Issuing & implementation of in-house safety rules, safety program or manuals including emergency plan & procedures " was ranked in the last position (6) within this group with RII of (0.450) and in the position 46 respect to allover groups. This indicates that this factor has moderate effect on safety performance.

4.4.7 Group 7: Safety Inspections

This group of factors contains two factors and was ranked in the 13th position overall groups with a RII of (0.469) which was revealed the important at this group respect to safety performance. Table 4-9 shows Safety inspections factors affecting safety performance.

Within this group, i.e. (Safety inspection), it was shown that, "safety inspections by the top management " was ranked in the 1st position with a RII of (0.430) and in the position(28) respect to overall factors. These results insure that, the project manager has an important role to attain and adopt the inspection process in the construction project which improves the safety performance. The project manager has his own responsibility towards the daily monitoring for all activities of the project. In addition, the project manager try to perform the project without accidents to increase his reputation for construction process in Sudan and the project manager is responsible for any accident expected to happen in the site.

Table 4-9 RII and Rank of Safety Inspections Group Affecting Safety Performance

Safety Inspections Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Safety inspections by the top management	38.5	26.9	21.2	7.7	5.8	2.15	0.430	1	28
Safety inspections by government (Ministry of Works and Municipalities)	32.7	25	13.5	13.5	15.6	2.54	0.508	2	66
Total						**2.35**	**0.469**		

"Safety inspection by government (Ministry of workers and municipalities)" was ranked in the 2nd position within this group and with RII of (0.508) and being in the (66) position respect to overall factors. This indicates that this factor has moderate effect on safety performance. In general, the inspection action is crucial as a controlling and monitoring tool to achieve the organization's objective orientations policy.

4.4.8 Group 8: Safety Meetings

This group of factors "safety meetings" contains three factors and was ranked in the 14 position respect to overall nineteen groups with a RII of (0.471). Table 4-10 shows the factors within this group.

Table 4-10: Safety Meetings Factors Affecting Safety Performance

Safety Meetings Factors	Percentage of Occurrence					Mean	RII	Rank within this	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Conducting safety meeting in the site by the site engineer	34.6	34.6	9.6	7.7	13.5	2.31	0.462	1	50
Conducting safety meeting before each activity begins	34.6	28.8	13.5	15.4	7.7	2.33	0.466	2	53
Attendance of safety meetings by top management	36.5	23.1	13.5	15.4	11.5	2.42	0.484	3	60
Total						**2.35**	**0.471**		

" Conducting safety meeting in the site by the site engineer " was ranked in the 1st position within this group with a RII of (0.462) and in the 50 position respect to all factors over the eighteen groups.

" Conducting safety meeting before each activity begins “was ranked in the second position with a RII of (0.466), but this factor was ranked in the position 53 respect to overall . This indicates that this factor has moderate effect on safety performance.

"Attendance of safety meetings by top management" was ranked in the 3rd position within this group with a RII of (0.484) but with position 60 for overall group's factors . This indicates that this factor has moderate effect on safety performance.

4.4.9 Group 9: Role of Government And Engineering Societies

This group of factors "Role of government and Engineering Societies" contains three factors and was ranked in the 12 position respect to overall groups with a relative importance index of (0.447) This indicates that this factor has moderate effect on safety performance. Table 4-11 shows the factors within this group.

Table 4-11 RII and Rank of Role of Government and Engineering Societies group Affecting Safety Performance

Role of Government and Engineering Societies	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Strict implementation of safety instructions	42.3	23.1	15.4	5.8	13.5	2.25	0.450	2	41
The punishment in case of violation of laws, standards, regulations & legislations of safety	46.2	21.2	7.7	7.7	17.3	2.29	0.458	3	48
Issuance of laws, standards and regulations for safety	38.5	28.8	17.3	7.7	7.7	2.17	0.434	1	31
Total						**2.24**	**0.447**		

With this group of factors as illustrated in Table 4-11, it is shown that, " Issuance of laws, standards and regulation for safety "was ranked in the 1st position with RII of (0.434), this factor was ranked in the position 31 respect to overall factors within the remaining groups.

" Strict implementation of safety instructions " was ranked in the 2nd position with a RII of (0.450); the factor was ranked in the position 41 respect to overall factors groups.

Finding also shows that "The punishment in case of violation of laws, standards, regulations & legislations of safety " was ranked in the 3rd position with a RII of (0.458); in addition, the factor was ranked in the position 48 respect to overall factors groups. This indicates that this factor has moderate effect on safety performance.

4.4.10 Group 10: Crane and Lifting Equipment

This group i.e. "Crane and Lifting Equipment" contains two factors and was ranked in the 3rd position respect to overall groups with a relative importance index value of (0.400). This group includes two factors only as shown in Table 4-12. The construction projects in our country as other countries construction works depends largely on the crane and lifting equipment, combined with the seriousness in the sites. Such job has a great role in influencing the level of safety.

This result obtained from Table 4-12 shows that, "Selection of licensed operator who having skill and efficiency " was ranked in the 1st position within this group and with RII of (0.384), this result reflect clearly that this factor has critical influence on the safety performance. The working process in cranes and lifting equipment is relatively difficult and dangerous process. The skilled and profession labors in these tasks should be aware with the safety conditions and requirements to be able to overcome any unexpected or uncontrolled accidents. Moreover, working in a high level is clearly jointed and integrated with the safety performance circumstances and both have interconnected actions. For this fact, the labors should be aware and trained strongly to use this equipment with care according to safety requirements.

Table 4-12 RII and Rank of Crane and Lifting Equipment Group Affecting Safety Performance

Crane and Lifting Equipment Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Selection of licensed operator who having skill and efficiency	44.2	30.8	17.3	3.8	3.8	1.92	0.384	1	13
Enforce limited amount weights to be lifted by crane with clear stickers shows the limits	44.2	25	17.3	5.8	7.7	2.08	0.416	2	19
Total						**2.00**	**0.400**		

“Enforce limited amount weights to be lifted by crane with clear stickers’ shows the limits" was ranked in the 2nd position with a RII of (0.416). This indicates that this factor has moderate effect on safety performance.

4.4.11 Group 11: Safety Educating and Training

This group of factors i.e. "safety educating and training" contains five factors and was ranked in the 15 position respects to overall groups with a relative important index of (0.472). Relatively, this group of factors is not in the critical position to affect safety performance in the construction industry in the Sudan in respect to other groups. Table4-13 summarizes the factors related to Safety educating & training factors affecting safety performance.

Table 4-13 RII and Rank of Safety Educating and Training Group Affecting Safety Performance

Safety Educating and Training Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Guidance and training of workers about safety	34.6	34.6	15.4	7.7	7.7	2.19	0.438	1	33
Safety poster	38.5	21.2	19.2	15.4	5.8	2.29	0.458	2	48
Training for first aid for all workers	38.5	26.9	15.4	3.8	15.4	2.31	0.462	3	50
Brochures and publications on safety	19.2	42.3	17.3	9.6	11.4	2.52	0.504	5	64
Safety seminars held by the management of the project	30.8	21.2	25	15.4	7.7	2.48	0.496	4	61
Total						**2.36**	**0.472**		

With this group of factors," Guidance and training of workers about safety" was ranked in the 1st position with a RII of (0.438). The continuous training and awareness campaigns will be useful to develop the labors skills and learning culture about the safety performance.

"Safety poster" was ranked in the 2nd position within this group and with a RII of (0.458). The factor was ranked in the position 48 respect to overall factors within all groups..To empower and strength such factor it may require showing these posters before the beginning of the projects and precisely in the mobilization stage while the flow of work is relatively tiny. This indicates that this factor has moderate effect on safety performance.

“Training for first aid for all workers" has also a moderate effect on safety performance. This factor was ranked in the 3rd position but with a RII of (0.462). Either the results will alarm the decision makers to ask the contractors or the sub contractors to provide certify showing their understanding of the safety conditions,problems and solutions in construction projects.

"Brochures and publications on safety" and "safety seminars held by the management of the project" was ranked in the last positions with RII of (0.504) and (0.496). In addition, these factors were ranked in the position 61 and 64 respect to overall groups. This indicates that this factor has moderate effect on safety performance.

4.4.12 Group 12: Disposal of Hazardous Materials and Waste

This group of factors i.e. "Disposal of Hazardous Materials and Waste" contains two factors and was ranked in the position 16 respects to overall groups with a relative important index of (0.483). Relatively, this group of factors has a moderate influence respect to the safety performance in the construction industry in the Sudan.

Table 4-14 summarizes the factors related to Disposal of Hazardous Materials & Waste affecting safety performance. The moderate influence of this group at the overall groups could be returned to the nature of the work within this group. Such hazardous materials can be removed from construction site are relatively small and not touchable in our country, so the contractors' responds towards these factors were a little bit weak .

Table 4-14 RII and Rank of Disposals of Hazardous Materials and Waste Group Affecting Safety Performance

Disposal of Hazardous Materials and Waste Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Develop a risk management plan	28.8	38.5	15.4	11.5	5.8	2.27	0.454	1	43
Develop a waste management plan	26.9	26.9	19.2	17.3	9.6	2.56	0.512	2	68
Total						**2.42**	**0.483**		

With this group of factors, "Develop risk a management plan" was ranked in the 1st position with a RII of (0.454).

"Develop a management plan for waste" was ranked in the second position with a RII of (0.512). This indicates that this factor has moderate effect on safety performance.

4.4.13 Group 13: Personal Protective Equipment

This group contains three factors. Table 4-15 illustrates respondent's opinion regarding the factor measuring safety performance. This group of factors i.e. "Personal Protective Equipment" was ranked in the 1st position among all other groups (18 groups) with a RII of (0.357). This result emphasizes the Personal Protective Equipment (PPE) is extremely important for any industrial construction and for each construction projects. Moreover, it can be a strong indicator for the safety performance in the project.

Table 4-15: RII and Rank of Personal Protective Equipment Group Affecting Safety Performance

Personal Protective Equipment Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
The use of gloves and face protection	57.7	21.2	7.7	7.7	5.8	1.83	0.366	2	7
The use of protective head	59.6	23.1	9.6	5.8	1.9	1.67	0.334	1	1
The use of protective feet	48.1	32.7	9.6	5.8	3.8	1.85	0.370	3	10
Total						**1.78**	**0.357**		

"The use of protective head" factor ranked in the first position among PPE group with RII = 0.334 also was ranked in the first position among all groups factors. This result indicates that respondents support PPE.

"The use of gloves and face protection" was ranked in the second position within this group and 7 within overall groups' factors with RII (0.366). The importance of this factor could be returned to the fact that, protecting the hands and the face from any external harmful materials and impurity will be critical for the safety conditions for the labors, in additions, the presence of such equipment and materials like (gloves and face protection) will absolutely, means the steadiness of the work without body injuries or human losses.

"The use of protective feet" factor ranked in the third position among PPE group with RII = 0.370 also was ranked in position among overall groups factors. The results show that, these three factors are too critical for the safety performance measurements. This can be explained by the fact that the hands, face, and feet are the key enablers for any person to do any task professionally and specially the labors in the construction.

4.4.14 Group 14: Excavation, Trenching and Shorting

This group contains three factors. Table 4-16 illustrates respondent's opinion regarding the factor measuring safety performance. This group of factors i.e. "Excavation, Trenching, & Shorting" was ranked in the 5 position among all other groups (18 groups) with a RII of (0.415).

"The use of barricade to prevent collapse of soil during work" was ranked in the first position within this group and 5 within overall groups of factors with a RII of (0.358). The result reflects the contractors' opinion about the importance of using bracing to protect the labors during the excavation and earth works.

Table 4.16 RII and Rank of Excavation, Trenching and Shorting Group Affecting Safety Performance

Excavation, Trenching, and Shorting Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
The use of barricade to prevent collapse of soil during work	55.8	21.2	15.4	3.8	3.8	1.79	0.358	1	5
Soil type in terms of coherence	19.2	50	26.9	1.9	1.9	2.17	0.434	2	31
Low level of groundwater below the excavation work	28.8	30.8	28.8	7.7	3.8	2.27	0.454	3	43
Total						**2.08**	**0.415**		

Improving the safety condition for the earth works and specially trenches not only reflects safety performance but also shows the value of human resources respect to the contractors and construction parties overall. Using these protection equipments will save the lives and create a safe and stable working conditions.

"Soil type in terms of coherence" was ranked in the 2nd position among this group with RII of (0.434) and in the 31 position respect to overall factors. This indicates that this factor has moderate effect on safety performance.

"Low level of groundwater below the excavation work" was ranked in the last position within this group with RII of (0.454) and in 43 position within all groups. This indicates that this factor has moderate effect on safety performance.

4.4.15 Group 15: Fire Prevention

This group of factor contains three factors. Table 4-17 illustrates respondent's opinion regarding the factor measuring safety performance. This group of factors i.e. "Fire Prevention" was ranked in the 10 position among all other groups (18 groups) with a RII of (0.439).

Table 4-17 RII and Rank of Fire Prevention Group Affecting Safety Performance

Fire Prevention Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Availability of adequate fire extinguishers in the site	44.2	23.1	17.3	7.7	7.7	2.12	0.424	1	22
Good storage of flammable liquids and combustible materials	44.2	21.2	7.7	17.3	9.6	2.27	0.454	3	43
Periodical maintenance of fire extinguishers which located in the site	51.9	15.4	7.7	11.5	13.5	2.19	0.438	2	33
Total						**2.19**	**0.439**		

"Availability of adequate fire extinguishers in the site " was ranked in the 1st position among this group with RII of (0.424) and 22 among all groups' factors. This result shows that, the contractors who have care about the existence of fire extinguishers will imply a good indicator of the safety performance conditions in the project and it probably improve safety performance.

"Periodical maintenance of fire extinguishers which located in the site" was ranked in the second position within this group with a RII of (0.438) and in the position of 33 in overall factors groups. This indicates that this factor has moderate effect on safety performance.

"Good storage of flammable liquids and combustible materials" was ranked in the last position (3rd) in this group with a RII of (0.454) and was ranked in the 43 of overall groups. This indicates that this factor has moderate effect on safety performance.

4.4.16 Group16: Transportation

This group of group contains three factors. Table 4-18 illustrates respondent's opinion regarding the factor measuring safety performance. This group of factors i.e. "Transportation" was ranked in the 8 position among all other groups (18 groups) with a RII of (0.431).

Table 4-18 RII and Rank of Transportation Group Affecting Safety Performance

Transportation Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Periodical maintenance for vehicles and machinery (Trucks, Loaders, Shovel...etc.)	28.8	38.5	26.9	1.9	3.8	2.13	0.426	1	26
Training the drivers of vehicles and heavy machines	40.4	25	21.2	7.7	5.8	2.13	0.426	2	26
Wearing seat belts during drive vehicles and machinery	42.3	19.2	21.2	9.6	7.7	2.21	0.442	3	38
Total						**2.16**	**0.431**		

With this group of factors "Periodical maintenance for vehicles and machinery (Trucks, Loaders, Shovel...etc.)" was ranked in the 1st position with a RII of (0.426) . In addition the factor was shown in the position 26 respect to overall factors.

"Training the drivers of vehicles and heavy machines" was ranked in the 2nd position with RII of (0.426). In addition, the factor was shown in the position 26 respect to overall factors. This indicates that this factor has moderate effect on safety performance.

Within this group of factors, "Wearing seat belts during drive vehicles and machinery" was ranked in the 3rd position with a RII of (0.442). Moreover, it ranked in the position 38 respect to overall factors. This indicates that this factor has moderate effect on safety performance.

4.4.17 Group 17: Economic Investment

This group of factors i.e. "Economic Investment" as shown in Table 4-19, was ranked in the 9th position respect to over all groups with a relative important index of (0.435). Within this group of factors, "Allocating specific budget for safety requirements " was ranked in the 1st position with a RII of (0.416) and was ranked in the 19.

Within this group of factors "Financial motivation to application of safety" was ranked in the 2nd position with a RII of (0.454) and with 43 respect to overall factors. This indicates that this factor has moderate effect on safety performance.

Table 4-19 RII and Rank of Economic Investment Group Affecting Safety Performance

Economic Investment Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Financial motivation to application of safety	42.3	19.2	15.4	15.4	7.7	2.27	0.454	2	43
Allocating specific budget for safety requirements	46.2	23.1	15.4	7.7	7.7	2.08	0.416	1	19
Total						**2.18**	**0.435**		

4.4.18 Group 18: Medical Facilities

"Medical Facilities" ranked in the 17th position respect to overall groups with a relative importance index value of (0.516).

Table 4-20 RII and Rank of Medical Facilities Group Affecting Safety Performance

Medical Facilities Factors	Percentage of Occurrence					Mean	RII	Rank within this Group	Rank within overall Factors
	Very High	High	Moderate	Low	Very Low				
Availability of medical apparatus in the site	25	32.7	17.3	5.8	19.2	2.62	0.524	2	69
Periodical medical examination of workers	30.8	19.2	21.2	15.4	13.5	2.62	0.524	3	69
Permanent presence of a medical specialist in the site (Availability of medical advice)	23.1	40.4	13.5	9.6	13.5	2.50	0.500	1	62
Total						**2.58**	**0.516**		

As shown in Table 4-20. This group of factors Permanent presence of a medical specialist in the site (Availability of medical advice)" was ranked in the 1st position and in the position 62 in overall factors group with a RII of (0.500).

" Availability of medical apparatus in the site " was ranked in the 2nd position and in the position 66 in overall factors group with a RII of (0.524).

“Periodical medical examination of workers " was ranked in the 3rd position with a RII of 0.524, This indicates that this factor has moderate effect on safety performance.

In general, these results demonstrate that the responding of the questionnaires medical facilities was not taken into account although it is very important factor and effects on the safety performance, in general, the medical facilities and conditions are not strongly checked within our construction projects.

The weak Relative indexes for this group ensure the argument that our construction companies have not the willingness to setup (Medical services in construction sites). In addition, have not the tendency to improve medical facilities conditions. Moreover, the results revealed that, intention and the willingness to conduct periodical medical examination for the workers are not clearly observed in our projects.

4.4.19 Summary Ranks of Group Affecting Safety Performance

Table 4-21 shows the rank of the groups; the ranks were arranged from high affecting safety performance in construction project to low.

The summary figures shown in Table 4-21 illustrated that, group of factors related to "Personal Protective Equipment's" was ranked in the first position among the eighteen groups with a score RII of (0.357). The importance of this group of factors could be returned to the fact that such group includes the main equipment that protects the worker from the daily working accidents. The protection of head, eyes, noise, hands and feet are covered in this group factors. This will be considering the first defense line to protect the workers and influence the safety performance. The results shown in Table 4-21 illustrated also that, the group of factors including" Signs, Signals and Barricades" was ranked in the second position respect to the remaining nineteen (18) group of factors with score a RII equal to (0.389).

Table 4-21 Ranks of Groups of Factors Affecting Safety Performance

Groups of Factors	RII	Rank
Personal Protective Equipment	0.357	1
Signs, Signals & Barricades	0.389	2
Crane & Lifting Equipment	0.400	3
Administrative & Management Commitment	0.412	4
Project Nature	0.415	5
Excavation, Trenching, & Shorting	0.415	5
Emergency Planning & Preparations	0.428	7
Transportation	0.431	8
Economic Investment	0.435	9
Fire Prevention	0.439	10
Historic, Human & Psychological Climate	0.446	11
Role of Government & Engineering Societies	0.447	12
Safety Inspections	0.469	13
Safety Meetings	0.471	14
Safety Educating & Training	0.472	15
Disposal of Hazardous Materials & Waste	0.483	16
Medical Facilities	0.516	17
Welfare Facilities	0.544	18
Total	**0.443**	

The results obtained from Table 4-21 shows that, the factors of {Crane & lifting Equipment, Scaffolding and Excavation, Administrative & Management Commitment} were higher than {Role of Government and Engineering Societies, Safety Inspections and Safety Meetings}.

4.4.20 Summary Ranks of Factors Affecting Safety Performance

Table 4-22 shows the rank of the factors related with their group. The ranks were arranged from high affecting safety performance to low.

Table 4.22 Summaries of Ranks for Factors Affecting Safety Performance

Related Group	Factors Affecting Safety Performance	RII	Rank
Personal Protective Equipment	The use f protective head	0.334	1
Project Nature	Scope of the project	0.342	2
Signs, Signals & Barricades	The use of barricades to close the site for the pedestrians	0.350	3
Signs, Signals & Barricades	The use of caution signs	0.350	3
Project Nature	Lighting the site during night working hours	0.358	5
Excavation, Trenching, & Shorting	The use of barricades to prevent collapse of soil during work	0.358	5
Signs, Signals & Barricades	The use of danger signs	0.366	7
Personal Protective Equipment	The use of gloves and face protection	0.366	7
Administrative & Management Commitment	Safety awareness of company's top management	0.366	7
Personal Protective Equipment	The use protective feet	0.370	10
Administrative & Management Commitment	Safety awareness of project managers	0.374	11
Historic, Human & Psychological Climate	Worker experience	0.380	12
Crane & Lifting Equipment	Selection of licensed operator who having skill and efficiency	0.384	13
Project Nature	Arrangement and organization the site (site environment)	0.396	14
Project Nature	Cost of the project	0.396	14
Administrative & Management Commitment	Availability a clear company's safety policy	0.404	16
Signs, Signals & Barricades	The use of instruction signs	0.412	17
Historic, Human & Psychological Climate	Relation between the supervisor and workers in the site	0.412	17
Crane & Lifting Equipment	Enforce limited amount weights to be lifted by crane with clear stickers shows the limits	0.416	19
Economic Investment	Allocating specific budget for safety requirements	0.416	19
Emergency /Disaster Planning & Preparations	Develop a plan to respond to emergencies	0.418	21
Historic, Human & Psychological Climate	Worker safety awareness, knowledge & involvement	0.424	22
Historic, Human & Psychological Climate	Interrelation between the workers in the site	0.424	22
Historic, Human & Psychological Climate	Relation between the management and workers in the site	0.424	22
Fire Prevention	Availability of adequate fire extinguishers in the site	0.424	22
Transportation	Periodical maintenance for vehicles and machinery (Trucks, Loaders, Shovel...etc.)	0.426	26
Transportation	Training drivers of vehicles and machinery	0.426	26
Historic, Human & Psychological Climate	Non-excessive overtime work for worker	0.430	28
Welfare Facilities	Provision of adequate facilities for first aid treatment	0.430	28
Emergency /Disaster Planning & Preparations	Develop a plan to respond to emergencies	0.430	28
Role of Government & Engineering Societies	Issuing laws, standards, regulations & legislations of safety	0.434	31
Excavation, Trenching, & Shorting	Soil type in terms of coherence	0.434	31

Emergency /Disaster Planning & Preparations	Training workers to respond to emergencies through the exercises	0.438	33
Administrative & Management Commitment	Management's attitude towards worker's welfare	0.438	33
Administrative & Management Commitment	Conduction of safety policy review	0.438	33
Safety Educating & Training	Guidance and training of workers to safety	0.438	33
Fire Prevention	Periodical maintenance of fire extinguishers which located in the site	0.438	33
Transportation	Wearing seat belts during drive vehicles and machinery	0.442	38
Project Nature	Application of new technology in construction projects	0.446	39
Welfare Facilities	Provision of food and drinking water	0.446	39
Administrative & Management Commitment	Issuing & implementation of in-house safety rules, safety program or manuals	0.450	41
Role of Government & Engineering Societies	Strict implementation of safety instructions	0.450	41
Disposal of Hazardous Materials & Waste	Develop a risk management plan	0.454	43
Excavation, Trenching, & Shorting	Low level of groundwater below the excavation areas	0.454	43
Fire Prevention	Good storage of flammable liquids and combustible materials	0.454	43
Economic Investment	Financial motivation to application of safety	0.454	43
Historic, Human & Psychological Climate	Worker age	0.454	43
Role of Government & Engineering Societies	The punishment in case of violation of laws, standards, regulations & legislations of safety	0.458	48
Safety Educating & Training	Safety poster	0.458	48
Historic, Human & Psychological Climate	Worker's ability to communicate with others	0.462	50
Safety Meetings	Conducting safety meeting in the site by the site engineer	0.462	50
Safety Educating & Training	Training of first aid for all workers	0.462	50
Signs, Signals & Barricades	The use of traffic signals in site	0.466	53
Historic, Human & Psychological Climate	Worker safety training received	0.466	53
Safety Meetings	Conducting safety meeting before beginning for each activity	0.466	53
Project Nature	Planning and scheduling of the project	0.470	56
Historic, Human & Psychological Climate	Worker accident's experience	0.470	56
Historic, Human & Psychological Climate	Worker education	0.470	56
Historic, Human & Psychological Climate	Decrease work pressure on workers	0.476	59
Safety Meetings	Attendance of safety meetings by top management	0.484	60
Safety Educating & Training	Safety seminars held by the management of the project	0.496	61
Project Nature	Clear and easy of project's design	0.500	62
Medical Facilities	Permanent presence of a medical specialist in the site (Availability of medical advice)	0.500	62
Historic, Human & Psychological Climate	Worker culture background	0.504	64
Safety Educating & Training	Brochures and publications on safety	0.504	64
Safety Inspections	Safety inspections by government (Ministry of Works and Municipalities)	0.508	66
Welfare Facilities	Provision of adequate toilets	0.510	67
Disposal of Hazardous Materials & Waste	Develop a waste management plan	0.512	68

Medical Facilities	Periodical medical examination of workers	0.524	69
Medical Facilities	Availability of medical apparatus in the site	0.524	69
Welfare Facilities	Provision of an ambulance in the site	0.562	71
Welfare Facilities	Provision of special places for smoking	0.774	72
	Total	**0.443**	

The result in table 4-24 depict that the most 5 important factor positively affecting safety performance in construction project in Sudan are: the use of protective head; Scope of the project; The use of barricades to close the site for the pedestrians; The use of caution signs; Lighting the site during night working hours; and The use of barricades to prevent collapse of soil during work with RII values of 0.334, 0.342, 0.350, 0.350, 0.358 and 0.358 respectively. On the other hand, results indicate Develop a waste management plan; periodical medical examination of workers; Availability of medical apparatus in the site; provision of an ambulance in the site; and provision of special places for smoking were the lowest factors positively affecting safety performance in construction sites in Sudan with RII values of 0.512, 0.524, 0.524, 0.562 and 0.774 respectively.

CHAPTER 5

CONCLUSION AND RECOMMENDDATIONS

5.1 INTRODUCTION

A literatures review was conducted to identify the factors affecting the safety performance in construction sites and to measure the construction safety of those companies. The objectives of this research are to identify the factors affecting the construction safety in Sudan and to provide rules for assessing the safety of construction companies and accordingly improve it.

Seventy-two factors were identified and grouped into eighteen groups. These factors were introduced via a questionnaire which was carefully designed to achieve the research objectives. The degree of impact of factors on safety performance in the respondent's company were evaluated based on a five- point Likert scale. The sample size was fifty-two construction companies in Sudan which participated in this study. The gathered data through the questionnaires were statistically analyzed to calculate the importance index of each factor presented on the questionnaire for the companies, accordingly these factors were ranked. The results of this study could be used by the construction companies to evaluate and assess their safety performance and practice relative to other construction companies, determine the reasons of success or failure, locate and identify the problem areas and determine the level of remedial effort to be applied.

5.2 CONCLUSIONS

1. The majority of the companies that were analyzed have not a safety department, while the others has such position or section. On the same line, the study showed that participated companies had a partially a safety program or manual represented. It can be concluded that the companies, which have not safety department, are unnecessary mean that are using a partially safety program or manual.

2. The parties that have the main responsibility of lacking safety during the construction in site according to the respondents are management, site engineer and safety engineer respectively. Worker came after the above parties' in the responsibility of safety lacking.

3. The majority of the respondents agreed that there is a financial saving by complying with safety provisions. On the other hand, the most significant impact of site accidents on construction companies is cost increasing. The other significant are impairing reputation of companies, imposing psychological burden on workers and interrupting project's schedule that means the respondents were in general more concerned about the cost, rather than internal distress of company image, the morale and the humanitarian aspect, and time.

4. The most important groups affecting safety performance agreed by large construction companies in Sudan are; personal protective equipment; signs, signals and barricades; crane and lifting; Administrative & Management Commitment, Project Nature; equipment and Excavation, Trenching, & Shorting. In addition, those for factors are; The use of protective head; Scope of the project; The use of barricades to close the site for the pedestrians; The use of caution signs; Lighting the site during night working hours and The use of barricades to prevent collapse of soil during work.

5. safety performance rules developed in this study can be considered as practical technique to assess and improve the company's safety performance. It is used to compare the company safety performance and practice with that of other construction companies in order to identify the areas need to be considered to improve the construction safety. This rules is available in this research and can be easily applied by construction companies.

6. A accidents data of the most companies are either not properly documented or are considered as confidential and not allowed to others, as they feared a bad reputation or further legal responsibility even though these data were for scientific research only.

5.3 RECOMMENDATIONS

Based on the conclusions identified previously, and the results obtained from this research, the following points can be recommended:

1. It is recommended to strengthen the awareness and attitude of the top management and project managers towards the importance of safety. The managements of the company must establish and enforce safety polices for workers and should develop their activities by including more monitoring of safety performance at the site and by giving more reliable feedback about the consequences that take place. Companies should hold their project management accountable for accidents.

2. It is recommended for the concerned government authorities to hire qualified, competent and certified engineers to conduct regular site inspections.

3. It is recommended for the company's management to conduct clear safety policy and periodically random safety inspections for technical

4. It is recommended to increase the efficiency of site safety inspections by using more qualified safety engineer with specific job description.

5. It is recommended to conduct formal safety meetings with all parties, such meetings are necessary for communicating safety information to all parties. Special meetings can be conducted before each new activity begins.

6. It is recommended that only experienced workers should be allowed to perform risky tasks, especially when using heavy machinery or powered tools and drive should be provided for new workers since they are the ones who are exposed to the danger of daily job hazards.

7. Emphases should be laid on investigation of indirect cost of accidents. These costs in addition of being greater than the direct costs, increasing the cost of construction. The costs of accidents present a serious drain of company's profit. Therefore, more attention will be paid to the economic investment in safety if the contractor realizes the fact that the costs of accidents are higher than the cost of safety.

8. It is recommended for the company to implement a system for safety incentive for the workers. It may not necessarily be the best tool to enhance safety performance of work site, but some form of incentive is important.

9. The government and the engineering societies should play a major role to apply the safety rules by issuing the regulations, standards and codes and legally enforced the companies to follow them with adequate strict penalties for non- compliance.

10. The concept of safety, in its broadest sense, should be taught in all stage of education. All media should pay attention to safety rules in all fields.

11. The owners and the engineer should enforce the contractor to comply with the safety requirements.

12. A safety provision should be stated in construction contracts. It should also be taken into consideration in the tendering stage. An adequate budget should be assessed to safety implementation.

13. Awareness campaign should be established to widen up the understanding of such signs and the importance of using it in various construction building, roads and water sewage projects.

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APPENDIX

APPENDIX-A.1

SAMPLE OF QUESTIONNAIRE USED FOR SURVEY (English)

بسم الله الرحمن الرحيم

Dear Sir

I am a graduate student at Sudan University of Science & Technology. I am Now preparing a master thesis in the construction engineering program. The title of the Thesis is:

"Factors affecting safety performance on construction sites in Sudan"

The purpose of the study is to identify and analyze the factors, which affect the Safety performance in construction sites in Sudan. The results of the study will be of Great help to the industry and offering valuable results for all. As you are one of the large organizations working in this field in Sudan, we Are kindly inviting you to participate in filling this questionnaire with the required Data which is an important element in this study. Please let your safety personnel or project manager provide the required Information requested in this questionnaire. The information provided by you will Be analyzed as whole, and we ensure you that this information will be held in strict Confidence and used for scientific research purpose only without mentioning the Name of your organization. We realize that there are numerous demands on your time. However your Involvement is a vital requisite for this study. We appreciate your anticipated Cooperation in answering this questionnaire, which may take less than 20 minutes of your valuable time.

Thank you for your anticipated cooperation.

Best regards.

Yours sincerely

Name: Osman Omer Osman Salih Phone number: 0911145646

Email: osman.omer2011@gmail.com

PART A: GENERAL INFORMATION

Please write or check the most appropriate answer for the following questions

1. Name of your company (optional)……..
2. What is your job title? ……
3. What is your company classification grade in the field of construction?

☐Building ☐ Highways ☐ Sanitation ☐ Other……...

4. How many years have your company in the construction field?

☐ less than 5 Years ☐ 5 to 10 years ☐ Over10 to 15 years ☐ Over 15 years

5. How many years you work in the construction field?

☐ Less than 5 years ☐ 5 to 10 years ☐ Over10 to 15 years ☐ Over 15 years

6. How old are you?

☐ 15 to 24 years ☐ Over 24 to 34 years ☐ Over 34 to 44 years ☐ Over 45 years

7. What is your scientific qualification?

☐ Secondary ☐ Diploma ☐ B.Sc. ☐ Master ☐Other……

8. How many Workers in your company?

☐ less than 50 ☐ 50 to 100 ☐ 100 to 200 ☐ Over 200

PART B: INFORMATION OF SAFETY

9. Does your company have a safety professional?

☐ Yes ☐ NO

10. Does your company have a safety department?

☐ Yes ☐ NO

11. Does your company use a safety program or manual?

☐ Yes ☐ Partially ☐ No

12. Do you have knowledge of the safety conditions, specification and provisions?

☐ Yes ☐ Partially ☐ No

13. In your opinion, who should be responsible for lacking of safety during construction on site? (You can select more than one answer for this question)

☐ worker ☐Safety Engineer ☐ Site Engineer ☐ Management

☐ Civil defense ☐ Others (Specify)

14. Do you expect any financial saving by complying with safety conditions, specifications and provisions?

☐ Yes ☐ Sometimes ☐ No

15. What is the most significant impact of site by accidents on construction companies?

	Very high	High	Moderate	low	very low
a. Increase cost	☐	☐	☐	☐	☐
b. Impairing reputation of companies	☐	☐	☐	☐	☐
c. Imposing psychological burden on worker	☐	☐	☐	☐	☐
d. Interruption project's schedule	☐	☐	☐	☐	☐

16. Total number of disabling injuries during last work year are?

☐ Less than 5 years ☐ 5 to 10 years ☐ Over10 to 15 years ☐ Over 15 years

17. Total number of workers last work year are?

☐ less than 50 ☐ 50 to 100 ☐ 100 to 200 ☐ Over 200

PART C : FACTORS AFFECTING THE SAFETY PERFORMANCE IN CONSTRUCTION PROJECTS

The list below includes the factors that affecting the safety performance in constrution industry.

For each of these factors you are kindly requested to express your opetion by answering the following question and placing (x) in the appropiate box what is the degree of impact of the factor on safety performance in construction project ?

No	Factors description	Degree of impact				
1	**Project Nature**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
1.1	scope of the project					
1.2	Cost of the project					
1.3	Arrangement and orgnization the site (site envirnoment)					
1.4	Plannning and scheduling of the project					
1.5	Application of new technology in construction projects					
1.6	Clear and easy of projects design					
1.7	Lighting the site during night working hours					

No	Factors description	Degree of impact				
2	**Emergency Planning & Preparations**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
2.1	Develop a plan to respond to emergancies					
2.2	Training workers to respond to emergancies through the exercises					

No	Factors description	Degree of impact				
3	**Sings, Signals & Barricades**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
3.1	The use of danger signs					
3.2	The use of caution signs					
3.3	The use of instruction signs					
3.4	The use of traffic signs					
3.5	The use of barricades to close the site for the pedestrians					

No	Factors description	Degree of impact				
4	**Historic , Human & Psychological Climates**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
4.1	Worker age					
4.2	Worker experience					
4.3	Worker eduction					
4.4	Worker culture background					
4.5	Worker safety training received					
4.6	Worker safety awareness knowledge & involvement					
4.7	Worker accidents experience					
4.8	Workers ability to communicate with other					
4.9	Relation between the management and workers in the site					
4.10	Relation between the supervisor and workers in the site					
4.11	Interrelation between the workers in the site					
4.12	Decrease work pressure on workers in the site					
4.13	Non excessive overtime work for worker					

No	Factors description	Degree of impact				
5	**Welfare Facilities**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
5.1	Provision of food and drinking water					
5.2	Provision of adequate facilities for first aid treatment					
5.3	Provision of an ambulance in the site					
5.4	Provision of adequate toilets					
5.5	Provision of special places for smoking					

No	Factors description	Degree of impact				
6	**Administrative & Management commitment**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
6.1	Safety awareness of company's top management					
6.2	Safety awareness of project managers					
6.3	Availability a clear company's safety policy					
6.4	Issuing & implementation of in-house safety rules safety program or manuals					
6.5	Conduction of safety policy review					
6.6	Management's attitude towards worker's welfare					

No	Factors description	Degree of impact				
7	**Safety inspections**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
7.1	Safety inspections by government					
7.2	Safety inspections by top management					

No	Factors description	Degree of impact				
8	**Safety meetings**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
8.1	Conducting saftey meeting in the site by the site engineer					
8.2	conducting safety meeting before beginning for each activity					
8.3	Attendance of safety meeting by top management					

No	Factors description	Degree of impact				
9	**Roie of government & Engineering societies**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
9.1	Issuing laws, standards, regulations & legislations of safety					
9.2	Supervision implement laws, standards, regulations & legislations of safety					
9.3	The punishment in case of violation of laws, standards, regulations & legislations of safety					

No	Factors description	Degree of impact				
10	**Crane & lifting Equipment**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
10.1	Selection of licensed operstor who having skill and efficiency					
10.2	Enforce limited amount weights to be lifted by crane with clear stickers shows the limits					

No	Factors description	Degree of impact				
11	**Safety Educating & Training**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
11.1	Guidance and training of worker's to safety					
11.2	Brochures and publications on safety					
11.3	Safety seminars held by the management of the project					
11.4	Safety posters					
11.5	Training of first aid for all worker					

No	Factors description	Degree of impact				
12	**Disposal of Hazardous Materials & Waste**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
12.1	Develop a risk management plan					
12.2	Develop a waste management plan					

No	Factors description	Degree of impact				
13	**Personal Protective Equipment**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
13.1	The use of protective head					
13.2	The use of protective feet					
13.3	The use of gloves and face protection					

No	Factors description	Degree of impact				
14	**Exavation, Trenching & Shorting**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
14.1	The use of barricades to prevent collapse of soil during works					
14.2	Soil type in terms of coherence					
14.3	Low level of groundwater below the Excavation areas					

No	Factors description	Degree of impact				
15	**fire prevention**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
15.1	Availability of adequate fire extinguishers in the site					
15.2	Good storage of flammable liqulds combustible materials					
15.3	Periodical maintenance of fire extinguishers which located in the site					

No	Factors description	Degree of impact				
16	**Transportation**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
16.1	Periodical maintenancefor vehicals and machinery					
16.2	Wearing seat belts during drive vechicles and machinery					
16.3	Training drivers of vehicles and machinery					

No	Factors description	Degree of impact				
17	**Economic Investment**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
17.1	Allocating specifi budget for safety requirement					
17.2	Financial motivation to application of safety					

No	Factors description	Degree of impact				
18	**Medical Facilities**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
18.1	Permanent presence of a medical specialist in the site					
18.2	Availability of medical apparatus in site					
18.3	Periodical medical examination of workers					

No	Factors description	Degree of impact				
19	**Please , Write Any Factors Were not Mentioned in this list**	**Very high**	**High**	**Modarate**	**Low**	**Very low**
19.1						
19.2						
19.3						
19.4						