

CHAPTER 1

1.1 INTRODUCTION

The construction industry is one of the largest operating industries in most countries of the world and that about half of the values of construction contracts is spent on manpower, so the importance of accidents prevention are critical in order to reduce the economic impacts that occur in construction companies.

Accident can be described as an unpleasant and unexpected event that causes injury, damages and could result to death, (Oladiran, Olatunji Joseph, 2009)

Construction accident injury lawsuits can be complex, because a variety of parties may be held liable, such as the site's landowner, your employer, the general contractor, prime contractor, subcontractor, construction managers or equipment and material suppliers, (Types of Construction Site Injuries, 2014, Internet).

According to the U.S. Occupational Health and Safety Administration, one out of every 5 workplace deaths each year involves a construction worker. In 2009 alone, 816 employees nationwide lost their lives due to an on-the-job construction accident. Many others suffered an injury at work that will impact their lives forever, (Types of Construction Site Injuries, 2014, Internet).

Thus, this research intends to examine the frequency of occurrence of different types of accidents and their causes on building sites and the economic impacts of site accidents on the construction companies in Khartoum State, Sudan.

1.2 Problem Statement

Accidents and work-related injuries in the construction industry represent a big problem facing construction companies because they involve big losses in physical and human elements which will reflect negatively on the level of performance and efficiency because of stops of working.

1.3 Objectives of Research

The aim of the study is to determine the construction accidents and their causes in construction sites in Khartoum state. The specific objectives of this study are as follows:

- I. To obtain an overview of construction accidents types in Khartoum state.
- II. To identify the causes of construction accidents and their relationship with management, worker, environment, social and job condition factors in order to decrease the sites accidents in Khartoum state.
- III. To identify and quantify the economic impacts of site accidents on the construction companies.
- IV. To identify which construction companies in Khartoum State have the insurance policy toward the workers, have department of occupational safety and safety program in order to improve safety performance in construction companies in Khartoum state.

1.4 Scope and Limitation of Study

1.4.1 Spatial Limitation

This study was confined in construction companies and construction sites located within the state of Khartoum only.

1.4.2 Temporal Limitation

This study was completed during 2014.

1.4.3 Human Limitation

The targeted respondents were persons who are very well about the construction works and in particular at sites accidents, such as project manager, site manager, site engineer and safety and health officer.

1.5 Significance of study

This research derives its significance from the importance of his theme the construction accident and their causes, and impact of these accidents to the companies, workers, and the cost and time of projects.

1.6 Previous research

There are some previous researches that are studying about the topic regarding construction accidents and their causes, which helped in data collection for literature review, the topics of previous researches are as below:

1. Accidents on Building Sites: Rate of Occurrence and Causes.
 - a. Author: Oladiran, Olatunji Joseph
 - b. Objective: the study examines the rate of occurrence of accidents and their causes on building sites in Lagos State
 - c. Year: 2009
2. Control Measure of accidents: Nigerian Buildings Projects' Case.
 - a. Author: Oladiran, Olatunji Joseph
 - b. Objective: The study explores the various safety and control measures (SCM) of accidents in building projects to minimize accidents' occurrence and consequent waste generation.
 - c. Year: 2008

CHAPTER 2

LITERATURE REVIEW AND SCIENTIFIC BACKGROUND

2.1 INTRODUCTION

Construction sites are known for high rate of occupational accidents, which present the field as one of the most dangerous workplace on earth (I.L.O., 2005). Seixas *et al* (1998) show that the occurrence of accident differs from one site to another. They further ascertained that strip and trip, major fall from heights, electrical accidents, impact hazards and so on are the major causes of accidents or most occurred type of accidents on any building sites. This means that one site could be more dangerous than the other, depending on the complexity of the work carried out on the site. (Oladiran, Olatunji Joseph, 2009).

2.2 Factors Responsible for the Occurrence of Accidents on Sites

There are many different factors responsible for the occurrence of accidents on construction sites these factors can be grouped as:

1. Acts of God: Siriwardena *et al* (2006) posit that acts of God or disasters as related to construction are events or actions, which causes severe damages to construction products, processes and stakeholders. Various acts of God that cause casualties on sites are rain, flooding, wind, lightning, earthquakes, land sliding, e.t.c. However, their occurrences are not frequent, but once they occur, the consequences are always high and disrupt activities of construction enterprises. Siriwardena *et al* (2006) further state that the effect of the acts of God or disaster to constructed items or items under construction has a huge direct impact on human lives, society and the economy. In other words, they could result in loss of lives, money, materials and time. Therefore, from the inception to the delivery of a construction project, safety procedures must be complied with on construction and building sites.

2. Environmental Causes: Environmental factors that could generate accidents on sites are:

i. Weather: Adeniye (2001) states that during the rainy season, many materials are wasted and manpower is lost on building sites. Thus, because of this environmental condition, it is much easier to carry out construction works on site during the dry season than the wet season. In the event of rain or hamarthan, a worker on scaffold may lose his balancing and step or slid off the plank, hence, resulting to fall. Sotire (1992) also points out that since construction workers work on an unsheltered environment, adverse weather conditions should be avoided because continuous exposure to adverse weather could lead to general discomfort and illness.

ii. Noise: Continuous exposure to moderately high noise level or relatively high level of impulse noise such as explosives on site, noise produced by heavy equipment, noise from carpentry works, welding works and aluminum works on site are the major causes of occupational deafness (Adeniye, 2001). Thus, continual exposure to this high level of noise produced on site could risk a site worker to future or occupational deafness or hearing problem; if effective control such as earplug is not provided and used. Therefore, noise on sites must be maintained at a bearable level or a noise protection provided.

iii. Dust: Dust is a common feature of any building site especially during dry seasons (Sotire, 1992). Exposure of workers to dust on site continuously could lead to eye problem, cough and respiratory disorder and allergies. Construction materials such as sand and cements; works such as demolition of existing structures and wood or carpentry works are the major producers of dust on site. Their inhalation could result in bodily and medical disorder on the workers; therefore, proper protection against dust on site must be provided for all site workers.

3. Faulty Machines: Though human errors are the main causes of accidents on sites, many mechanical causes of accidents are due to internal mechanical breakdown involving the steering mechanism, brake system, e.t.c (Fischer, 1998). According to him, a loader collided with the wall of a building as a result of the machine suddenly became unsteerable. The reason was a broken rear axle bearing of the machine while in operation; which is a mechanical fault. Though the loader was in perfect condition before the time of accident, it developed mechanical fault that resulted to accident. Conditions of

machine such as brakes, steering, oil level, water level and tyre conditions must be checked before operated to prevent any forms of mechanical fault that could develop thereafter.

4. **Human Error:** Human error was considered to be an undesirable human decision or action that reduces or has the potential for reducing the effectiveness, safety or system performance (Lucy *et al*, 1999). They further ascertained that almost all of construction accidents, whether minor or major, resulted from the action of individuals rather than externally imposed factors. This error could be due to failures on the part of construction workers themselves while on site, as a result of unsafe attitude of the workers, error in judgments, lack of concentration at work, lack of awareness on the danger surrounding the activities and safety requirements. Thus, there must be adequate safety training for all construction and building site workers, and personnel on site to raise their awareness level about safety, ensuring safe attitude on site and in return, reducing the potential of occurrence of accident on sites.

2.3 Accidents and Preventions' Methodologies

According to Lubega et. al (2001), the important characteristics of every construction project are the cost, duration, quality and safety of such project. They further argue that there has been a greater emphasis on the first three aspects, at the expense of safety. A lot of people have been exposed to risk situation on building sites, resulting in a high chance of accidents as a result of lack of adherence or inadequate provision of safety requirements. This implies that, a lot of contractors in the building industry are much more concerned about the cost, time and quality of the project delivery but are less concerned about the safety of the workers, who eventually are the facilitator of the project delivery to cost, time and quality, Gangwar and Goodrum (2005) mention that control of accidents on any building site is not the responsibility of just one person, but of everyone that participate in the production of such projects on site. On the other hand, Mwombeki (2005) enumerates four preventive approaches for accidents:

2.3.1 Safety Plans.

Management of any construction firm has the responsibility of developing a comprehensive and written safety programme that is performance oriented. The information should include the basics of personal protective equipments, the proper use of tools and power equipments, safe work practice, company policy on safety, safety responsibilities, emergency procedure, e.t.c. This document must be made available to every worker on site and adherent to it must not be compromised. The responsibility of the safety personnel shall be to draw up a safety plan, setting out the rules applicable to the construction or building site, and shall make any adjustment to the plan, ensure effective distribution and use of safety equipment.

2.3.2 Safety Training and Meeting.

Safety training is an essential part of any safety and health programme. Safety personnel and site workers should be trained in hazard identification, control and method of encouraging safe practices. The safety training and meetings must emphasize the project's safety requirements, review past activities, plan ahead for new operations, discuss the causes of accidents on site and ways of preventing future occurrence. This training should be provided in the language well understood by the workers (Hassanein and Hanna, 2007).

2.3.3 First Aid and Medical Arrangement.

First aid facilities must be provided on site regardless of the size of the project and the number of workers on site. In case of any injury such as cuts, strips or trips; prompt treatment with first aid facility can help prevent further aggravation of such injury. The employer should be responsible for the provision of first aid facility and personnel at all time on site (Hassanein and Hanna, 2007).

2.3.4 Management Policy.

The type of management policy or commitment to safety at workplace is very essential to the prevention of accidents. The various commitment of construction management are in drawing up of an effective safety plans, provision of protective equipments for all site workers and

personnel, encourage safe working habits, incentives for safety and regular review of accident prevention or safety programmes.

All of these accident preventive measures and many more are required on site to effectively prevent or reduce the occurrence of accident on building sites.

In the same vain, Tappin *et. al* (2001), Health and Safety Executive (H.S.E.) (2007) and Occupational Safety and Health Administration (O.S.H.A.) (2005) outline preventive measures as:

1. Wearing clothes that are appropriate to the work and weather condition on site.
2. Wearing of hand gloves.
3. Wearing of work traction boots at all times on site.
4. Wearing of hardhats or helmet at anywhere on site.
5. Provision of eyewear or goggle for welding purposes e.t.c.
6. Constant inspection and assessment of equipments, plants, tools and other site materials before use.
7. Organizing effective safety training for all site workers and personnel whether on site or off site.
8. Provision of effective first aid facility and personnel on site.
9. Provision of barriers, signs or reflector around dangerous areas on site (e.g. barrier around trench and so on)

2.4 Types of Accidents and Control Measures on Construction Projects

There are many various types of construction accidents and their respective control measures in construction projects, (Oladiran, Olatunji Joseph, 2008) such as:

2.4.1 Scaffold Accidents

Fall of person from scaffold and collapse of scaffolds has constantly been the number one killer in Hong-Kong construction industry (U.S Department of Labour, 2005). Between 2000 and 2004, the department shows that fatal accident arising from bamboo scaffold and working on platform have accounted for nearly half of the total number of fall-from-height fatal accidents in the period. Similarly, O.S.H.A (2005) reports that hazards occur due to improper erection of

scaffold. They add that 4,500 injuries and 50 fatalities from 2.3 million construction workers annually can be prevented with proper erection and use of scaffolds.

Various ways of controlling scaffold accidents on sites according to O.S.H.A (2005); H.S.E (2004); and McCann and Paine (2002) are:

1. Scaffold must be checked to be sound, rigid and sufficient enough to carry its own weight plus four times the maximum intended load without settling or swaying.
2. Scaffold must not be erected, moved, dismantled or altered except under the supervision of a competent person.
3. Unstable objects such, as boxes, loose bricks or concrete blocks must not be used to support scaffold or planks on scaffold.
4. Scaffold should be used with safety net and belt especially when use for works at height.
5. Scaffold accessories such as braces, brackets, trusses or screw legs that are damaged or weakened from any cause must be immediately repaired or replaced.
6. A competent person must inspect the scaffold and re-inspect at designated intervals.
7. Scaffold must be at least 10 feet away from any electric power lines at all time to avoid any forms of electrocution or contact with live cable.

2.4.2 Accident Due To Slip, Trip and Falls

Tappin et. al (2004) report that an increase in international and national attention is being placed on occupational strips, trips and falls (STF) as the extent of the problem is recognized. This growing interest reflects an understanding that strips, trips and falls are preventable in lieu of daily occurrence on building sites. More than a million people suffer from these accidents annually. In the same vein, Hinze and McGlothlin (2002) report that slips, trips and falls account for 15% to 20% of all workers' compensation cases; with older ones having higher percentage of falls compare to younger ones. This is as a result of the fact that, regardless of the kind of work to be done or the position of such work, slip or trip falls can occur at any place or point on the construction site, thus, the reason for its control to prevent casualty.

Slip and trip injury could be controlled on sites by the following ways according to Tappin et al (2001), H.S.E (2007) and O.S.H.A (2005):

1. The floor must be kept clean and dry always.
2. Immediate cleaning of spillage on site.
3. Immediate disposal of waste materials from site.
4. Avoid causing trailing cables or littering binding wires.
5. Constant wearing of suitable and traction footwear on site.
6. Immediate removal of any obstructions on the walk way on site.
7. Keep the site clear of any obstacle such as debris, broken blocks or concrete.

2.4.3 Crane Accident

Factors associated with mobile cranes failure include support failure, failure to use outriggers, crane failure or collapses and rigging failure. Though, the collapse of tower cranes is rare, accidents and near misses do occur. Failure of any part of the crane or load carry systems are likely to cause serious accidents, with both crane operators, site personnel and general public involved (Skinner et. al, 2006). Similarly, O.S.H.A (2005) posits that significant and serious injuries of fatality may occur if cranes are not inspected before use and if they are not used properly. Often, these injuries occur when a worker is struck by an overhead load or caught within the crane's swing radius. It therefore implies that, crane accidents are associated with erection or assembling, usage, dismantling and supervision or inspection and are major treat to life of workers on any building site.

The ways of curbing crane accidents on building and construction sites are stated below according to Neitzer et. al (2001), O.S.H.A (2005) and Skinner et. al (2006).

1. Checking of all crane control to ensure proper operation before use.
2. Inspection of wire rope, chains and hook for any damage.
3. Ensuring that the load does not exceed the crate rated or carrying capacity.
4. Full check of all rigging prior to use.
5. Fully extend of outriggers before full operation.
6. Never move a load over a worker.

7. The load must be raised few inches to verify balance and effectiveness of the brake system.
8. Watch for overhead electrical distribution and transmission lines and maintain a safe working clearance of at least 10 feet from energized and electrical lines.

2.4.4 Ladder Accident

Ladder falls or accidents increased significantly in 2001-2005, which gives a significant rise in serious injury from ladder falls (Mitra et. al, 2007). This was shown in their investigation of 4553 site workers presented to Victorian Hospital with injuries from ladder fall. Of these, 160 patients were classified as major trauma case. A fall from height, more than one meter, was the most common mechanism of injury accounting for 59% of the total. It was also established that about 20% of ladder-related falls greater than one meter and major trauma cases occurred while people are working on site. Mitra et. al (2007) state further that, despite the knowledge of the dangers of falls from ladders, there has been a significant increase in the number of casualties from ladder falls which resulted into broken limb, fracture and bruises on building sites.

The control measures according to Mitra *et al* (2007) and O.S.H.A (2005) include:

1. The use of correct ladder for the task or job.
2. Ladders are ensured to be long enough to safely reach the work area without unnecessary reaching to the sides.
3. Avoidance of the use of ladder, especially metallic, near electrical work and overhead lines.
4. Never load ladders beyond the maximum intended load or beyond the manufacturer's rated capacity.
5. Mark or tag (do not use) damaged or defective ladders for repair or replacement to prevent their usage.

2.4.5 Electrocution and Electrical Accidents

McCann and Paine (2002) reveal electrical and electrocution death on site between 1992 and 1998 that, out of the 1,019 deaths (146 cases yearly), 1,002 are electrocution and 17 are

electrical arc flashes on sites. It implies that electrical works involving the use of electricity on site is very risky. He further shows that most people affected by electrocution or electrical injuries are electrical workers (i.e electricians; electrical power installers and repairers; their apprentices and their supervisors). These workers had one-third of the electrical deaths or electrocution followed by general laborers on site. In addition, Taylor et. al (2002) also conclude that the majority of electrocution death resulted either from direct or indirect contact with power lines; but having the power de-energized in close proximity to building sites and other settings, where there are potential for power line contact reduces this hazard. Where not possible or practicable to de-energize lines, adequate clearance must be maintained or lines encased in insulated sleeves to prevent electrocution of whatever kind.

The control measure as highlighted by McCann and Paine (2002); Taylor et al, (2002), Cawley and Homce, (2001) include:

1. All electrical workers must wear a non-conductive hand glove at work.
2. De-energizing of electrical lines in proximity to construction sites
3. Ensuring that all cables are in proper conditions before switch in on the machine.
4. Adequate provision of personal protective equipments on site

2.4.6 Hazard Communication

Failure to recognize the hazards associated with chemicals can cause chemical burns, respiratory problems, fires and explosions. The control measures according to O.S.H.A (2005) include:

1. Maintain a Material Safety Data Sheet (MSDS) for each chemical in the facility.
2. Make this information accessible to employees at all times in a language or formats that are clearly understood by all affected personnel.
3. Train employees on how to read and use the MSDS.
4. Follow manufacturer's MSDS instructions for handling hazardous chemicals.
5. Train employees about the risks of each hazardous chemical being used.
6. Provide spill clean-up kits in areas where chemicals are stored.
7. Have a written spill control plan.

8. Train employees to clean up spills, protect themselves and properly dispose of used materials.
9. Provide proper personal protective equipment and enforce its use.
10. Store chemicals safely and securely.

2.4.7 Forklifts Accidents

Approximately 100 employees are fatally injured and approximately 95,000 employees are injured every year while operating powered industrial trucks. Forklift turnover accounts for a significant number of these fatalities O.S.H.A (2005). The control measures according to O.S.H.A (2005) include:

1. Train and certify all operators to ensure that they operate forklifts safely.
2. Do not allow any employee under 18 years old to operate a forklift.
3. Properly maintain haulage equipment, including tires.
4. Do not modify or make attachments that affect the capacity and safe operation of the forklift without written approval from the forklift's manufacturer.
5. Examine forklift truck for defects before using.
6. Follow safe operating procedures for picking up, moving, putting down and stacking loads.

2.4.8 Trenching Accidents

Trench collapses cause dozens of fatalities and hundreds of injuries each year. Trenching deaths rose in 2003. The control measures according to O.S.H.A (2005) include:

1. Never enter an unprotected trench.
2. Always use a protective system for trenches feet deep or greater.
3. Employ a registered professional engineer to design a protective system for trenches 20 feet deep or greater.
4. Protective Systems:
 - Sloping to protect workers by cutting back the trench wall at an angle inclined away from the excavation not steeper than a height/depth ratio of 11 2 :1, according to the sloping requirements for the type of soil.

- Shoring to protect workers by installing supports to prevent soil movement for trenches that do not exceed 20 feet in depth.
- Shielding to protect workers by using trench boxes or other types of supports to prevent soil cave-ins.

5. Always provide a way to exit a trench--such as a ladder, stairway or ramp--no more than 25 feet of lateral travel for employees in the trench.
6. Keep spoils at least two feet back from the edge of a trench.
7. Make sure that trenches are inspected by a competent person prior to entry and after any hazard-increasing event such as a rainstorm, vibrations or excessive surcharge loads.

2.4.9 Tools and Falling Objects

Objects can fall in cases where a manager or a subcontractor failed to take into account the weather that day. Unfavorable conditions such as wind, rain, or ice can make objects slippery, which can cause objects to fall from scaffolds or platforms and other places. Or, perhaps a worker was tired or distracted, or under the influence of alcohol and he failed to follow the safety rules or failed to follow OSHA regulations (Morris County Construction Accident Lawyer, 2014).

Falling objects can cause a host of injuries including but not limited to:

1. Traumatic brain injuries (TBI)
2. Spinal cord injuries (leading to temporary or permanent paralysis)
3. Broken bones
4. Amputation injuries
5. Internal injuries
6. Blindness
7. Death

The control measures according to O.S.H.A (2005) include:

1. Wear hardhats.
2. Stack materials to prevent sliding, falling, or collapse.
3. Use protective measures such as toeboards and debris nets.
4. Use safety glasses, goggles, face shields, etc., where machines or tools may cause flying particles.
5. Inspect tools, such as saws and lathes, to insure that protective guards are in good condition.
6. Make sure you are trained in the proper operation of powder actuated tools.

2.5 Accidents Injury Types

A quick examination of any construction site reveals a number of potential hazards. Laborers are often seriously injured in workplace falls and accidents involving heavy machinery and falling objects, in addition to accidents resulting from improper signaling, poor cleanup and/or site maintenance and other negligent oversights. The impact of these construction accidents can be devastating for workers, causing personal injuries that may include the following (Types of Construction Site Injuries. Internet, 2014):

1. Amputations
2. Burns
3. Electrocution
4. Eye Injuries
5. Fractures
6. Knee & Ankle Injuries
7. Paralysis
8. Post-Traumatic Stress Disorder
9. Shoulder Injuries
10. Spinal cord injuries
11. Toxic exposure
12. Traumatic brain injuries (TBI)

2.6 Global Statistics on Construction Accidents and their Causes

2.6.1 Investigation in Great Britain (2013)

Figure 1 show that the number and rate of fatal injuries to workers in construction in Great Britain construction, Construction accounted for 5% of the employees in Britain and 6% of reported injuries to employees.

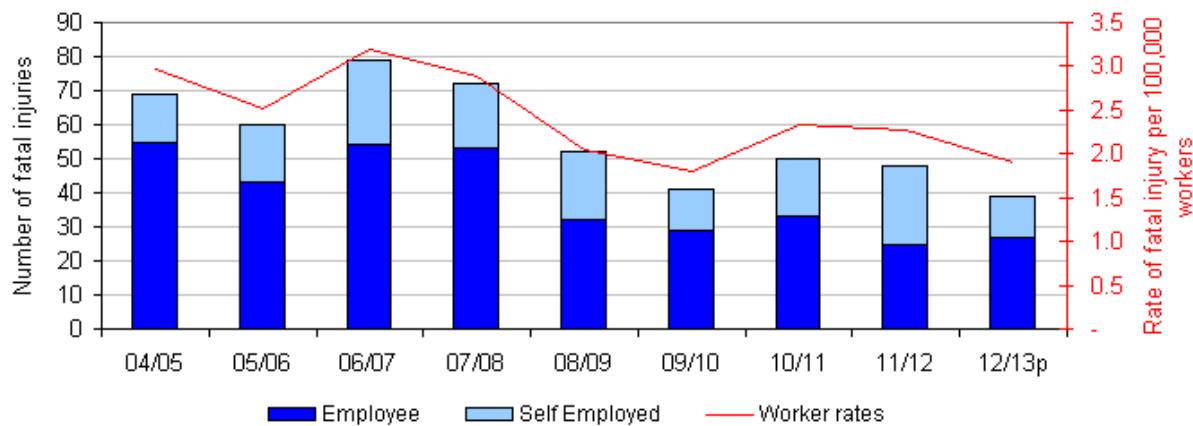


Figure 1 Number and rate of fatal injuries to workers in construction in Great Britain, 2013

There were 39 fatal injuries to workers in Construction in 2012/13p, 12 of these fatalities were to the self-employed. This compares with an average of 53 over the previous five years, including an average of 18 to the self-employed.

The rate of fatal injury per 100 000 construction workers was 1.9 in 2012/13p compared with a five year average of 2.3.

In 2012/13p, 26% of all fatal injuries to workers were in Construction and it accounts for the greatest number of fatal injuries of the industry sections.

The number of fatalities has fallen substantially since 2010/11, returning to the level seen in 2009/10. The rate reduction in 2012/13p is welcome, but could be easily reversed in a sustained recovery. (Health and safety in construction in Great Britain, 2013)

- **The main causes of workers fatalities**

Table 1 and figure 2 show that the main causes of worker fatalities in Great Britain construction.

Injury kind	Construction2012/13p
Falls	59%
Being struck by a falling/moving object	3%
A collapse/overturn	5%
Being hit by a moving vehicle	10%
Electricity	5%
Others	18%

Table 1 The main causes of workers fatalities in Great Britain, 2013

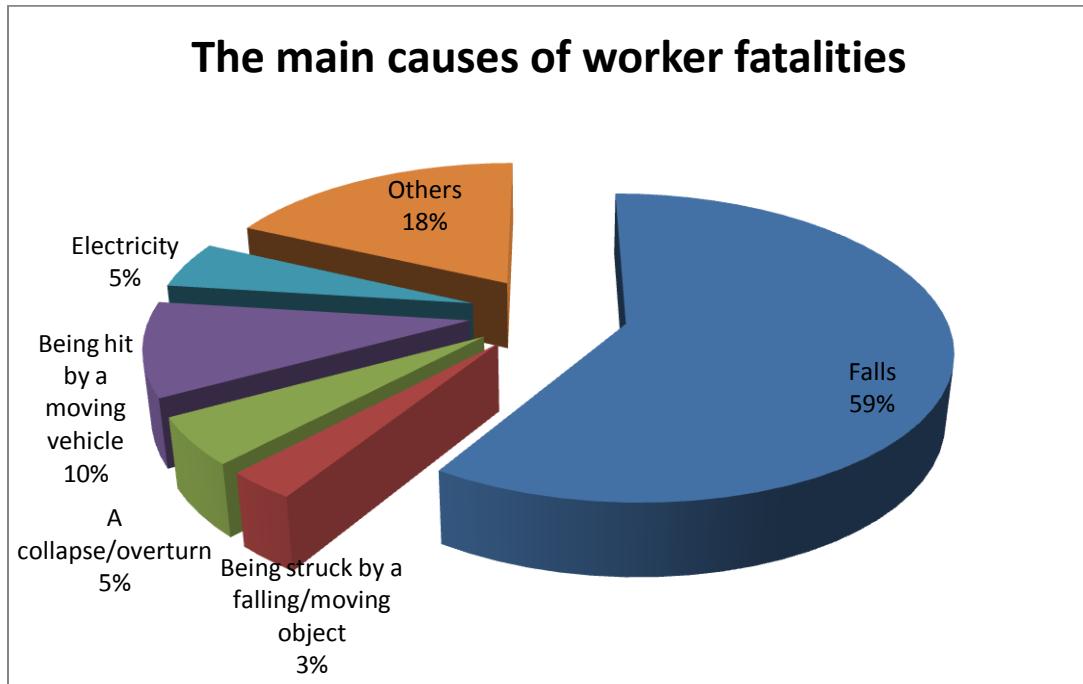


Figure2 The main causes of workers fatalities in Great Britain, 2013

- **The most common causes of major injury to employees**

Table 2 and figure 3 and 4 show that the most common causes of major injury to employees

Injury kind	Construction2012/13p
Falls	28%
Slips, trips and falls on the level	28%
Being struck by moving/falling objects	15%
Handling	8%
Others	21%

Table 2 The most common causes of major injury to employees in Great Britain, 2013

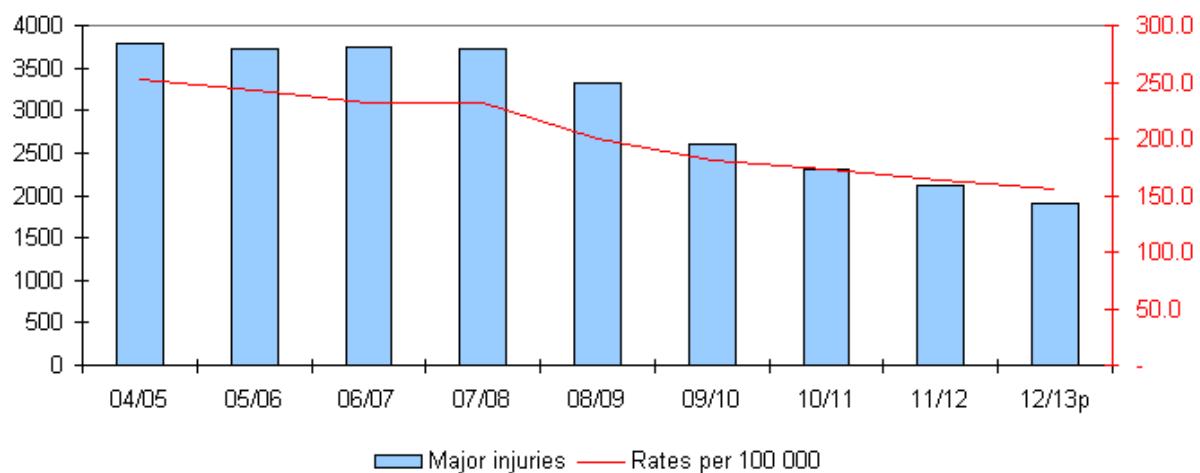


Figure 3 Number and rate of major injuries to employees in Britain construction industry, 2013

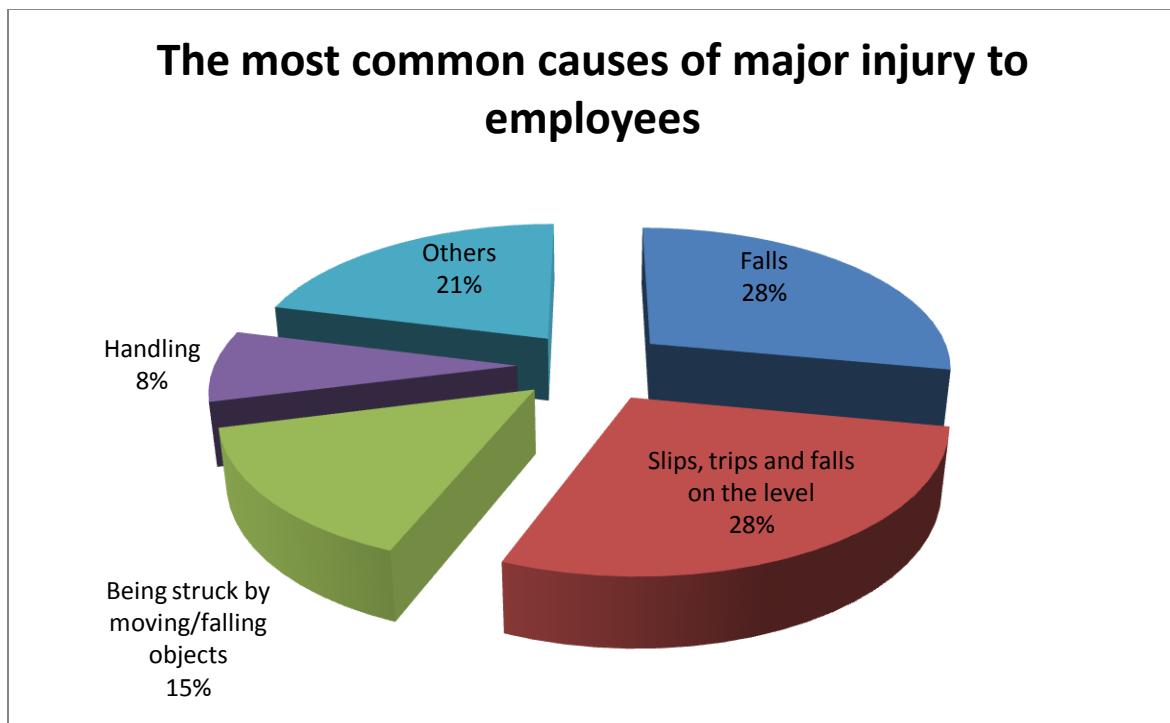


Figure 4 The most common causes of major injury to employees in Great Britain, 2012\2013

2.6.2 Investigation of Causes of construction accidents in USA

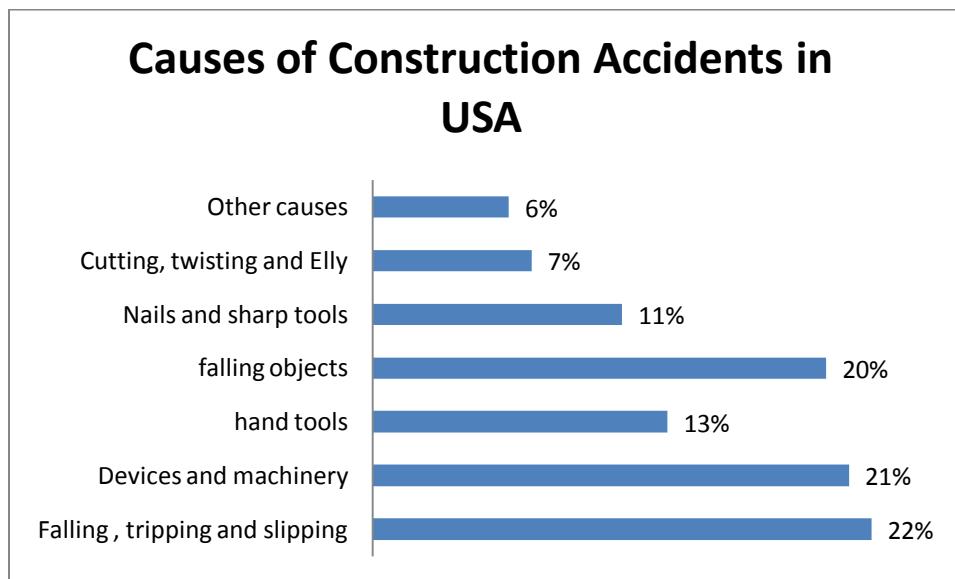


Figure 5 Investigation about causes of construction accidents in USA ,(Raafat Saeed Mousad, CETS)

2.7 The Economic Impacts of Construction Accidents

The official statistics of site accidents do not only represent terrible human tragedies but also substantial social and economic impacts on society. The social impact of site accidents could be defined as the effect that touches the human side of the society, where the economic impact could be defined as the effect that relates to the financial aspects of the society. All society members such as employees, families, employers, economy and resources will be affected somehow by the occurrence of a site accident.(Mthalane D, Othman AAE, Pearl, RG, 2008).

There are three kinds of costs when dealing with safety in construction:

- Direct costs of accidents and insurance
- Indirect costs of accidents
- Costs of safety programs

2.7.1 Direct costs of accidents and insurance

Direct costs include (Jeffrey S. Oakley, internet):

1. Lost wages
2. Medical Expenses
3. Insurance premiums & administration
4. Property damage

2.7.2 Indirect costs of accidents

Indirect costs include (Improving Construction Safety Performance,1990):

1. Loss of productivity
2. Disrupted schedules
3. Administrative time for investigations and reports
4. Training of replacement personnel
5. Wages paid to the injured worker (s) and other workers for time not worked
6. Clean up and repair
7. Adverse publicity
8. Third-party liability claims against the owner
9. Equipment damage

2.7.3 Costs of safety programs

Costs of safety programs include (Improving Construction Safety Performance,1990):

1. Salaries for safety, medical and clerical personnel
2. Safety meetings
3. Inspection of tools and equipment
4. Orientation sessions
5. Site inspections
6. Personal protective equipment
7. Health programs such as respirator-fit tests
8. Miscellaneous supplies and equipment

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Methodology

The study had been conducted through several phases namely literature review, data collection, data analysis, discussion and conclusion. A literature review was conducted encompassing all various means available to obtain the widest range of the relevant information from books, papers, previous researches and websites related to the causes of accidents in construction sites and economic impacts of accidents in construction companies.

3.2 data collection

A Questionnaire was used to obtain the data needed for research because it is one of the most important tools to collect the primary data and use it to achieve the purposes of research.

The data collection is based on 40 returned questionnaires in 2 month, which Distributed to a group of construction companies and construction sites in the state of Khartoum

The targeted respondents were persons who are very well about the construction works and in particular at sites accidents, such as project manager, site manager, site engineer and safety and health officer.

3.3 Questionnaire Design

The questionnaire (attached as an appendix to this research) was divided into three parts:

3.3.1 Part1: Accidents and Company Information

The first part of the questionnaire was about accidents and company information.

1. Type of accidents (e.g. Contact with electricity, Crane accidents, Gas explosion, Tool accidents, Exposure to fire, Structure failure, Fall from height, Exposure to hazardous material, Trench accidents, Fall from ladder, Slip/trip fall same level, Scaffolding, Natural causes, Falling object from height, Fall from roof opening, Machinery vehicle, Drowning, Asphyxiation).
2. Does the company have any insurance policy toward the workers?
3. Does the company have department of occupational safety?
4. Is there a safety program in the company?

3.3.2 Part2: The Factor and Causes which Led to Accident Occurred

The aim of this part is to carefully examine and focus on the causes of accidents that occur in order to decrease the sites accidents in Khartoum state.

Then a total of 17 causes of accidents were categorized in four groups: management factor, worker factor, job condition factor and environment and social factor.

Factor Related to the Management:

M1: Correct tools were not used for the specific task.

M2: Lack of supervision and control on worker's adherence to wear safety items.

M3: Safety regulations were not followed.

M4: Safety items were not available on site.

M5: No training program for the worker to implement the job.

Factor Related to the Worker:

- W1: The worker was suffering from health problems.
- W2: Physical fatigue caused the accident.
- W3: Worker was rushing the work.
- W4: The accidents occurred due to misjudgment from the worker.
- W5: The worker had not enough sleeping hours.
- W6: Worker was not wearing personal protection items.
- W7: Lack of knowledge by worker on wearing personal safety items

Factor Related to the Job Condition:

- J1: No enough rest times during the task.
- J2: Weather conditions were extreme.
- J3: Job or task was too difficult to perform.

Factor Related to the Environment and Social:

- E1: No cohesiveness among job crew.
- E2: Unsuitable living, housing and transportation facilities for the worker.

3.3.3 part3: The Economic Impact of Site Accidents on the Construction Companies:

The aim of this part is to identify and quantify the economic impacts of site accidents on the construction companies in state of Khartoum

This part consists of 13 economic impacts on construction companies by site accidents are as follows:

1. Loss of productivity
2. Disruption of current work
3. Training costs for new workers
4. Damages to plant, equipment, completed work
5. Corrective actions to prevent re-occurrence of accident
6. Deterioration of the efficiency of the team
7. Expenditures on emergency equipment
8. Costs of workman's compensation insurance
9. Increase of Medical payments
10. Costs of rescue operations and equipment
11. Payments of injury or death claims
12. Legal fees for defense against claims
13. Increased insurance costs

3.4 Data analysis

The first part of the questionnaire was analyzed using statistical analysis to obtain an overview of construction accidents types in Khartoum state.

And used **yes** or **no** mode to determine if the companies had insurance policy toward the workers, had a department of occupational safety or it had a safety program or no.

Part 2 and part 3 was answered by choosing if they it highly agree, agree, is neutral, disagree, or highly disagree. This range used a 5-point scale. For example, a highly agree answer Indicates the highest effect and a value of 5 was attached to it, while a highly disagree answer has the lowest effect and a value of 1 was given to it.

Relative Important Index (RII) was used to determine the ranking of the different factors causing construction accidents as outlined in the second part and the economic impacts of site accidents in construction companies as outlined in the third part, by using the following expression:

$$RII = \frac{\sum_{i=1}^5 aix_i}{5 \times N}$$

Where:

- ai** is a constant expressing the weight of the *i*th response.
- xi** is the frequency of the *i*th response of the total responses for each causes.
- i** is the response category index where *i* = 1,2,3,4 and 5 respectively.
- N** is the total number of respondents.
- RII** value is ranged between 0 to 1.

CHAPTER 4

RESULTS ANALYSIS AND DISCUSSION

4.1 Type of accidents

Table 1 shows the distribution of accidents types in Khartoum state. The most common types are Scaffolding accidents (70%), Fall from height accidents (67.5%), Tool accidents (60%), Falling object from height (50%) and Contact with electricity (40%).

Table1. Distribution of accidents types in Khartoum state

Types of accidents	Frequency	Percentage (%)
Contact with electricity	16	40%
Crane accidents	8	20%
Gas explosion	1	2.5%
Tool accidents	24	60%
Exposure to fire	4	10%
Structure failure	7	17.5%
Fall from height	27	67.5%
Exposure to hazardous material	3	7.5%
Trench accidents	14	35%
Fall from ladder	14	35%
Slip/trip fall same level	6	15%
Scaffolding	28	70%
Natural causes	6	15%
Falling object from height	20	50%
Fall from roof opening	15	37.5%
Machinery vehicle	12	30%
Drowning	4	10%
Asphyxiation	3	7.5%

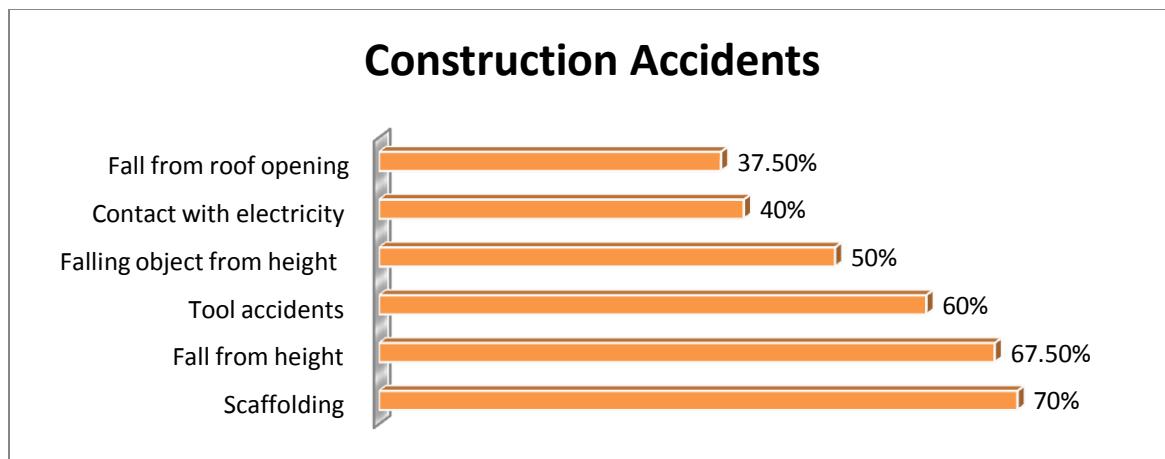


Figure1 The most common types of Accidents in construction sites in Khartoum state, Researcher

4.2 Factors Contributing To Construction Accidents in Khartoum

Table 2 shows the ranking of factors contributing to construction accidents in Khartoum state , The top causes were divided to four factors, such as five causes related to management factor, four causes related to the worker factor, one cause related to job condition factor and one cause related to the environment and social factor. These top causes are as follows:

1. M2 : Lack of supervision and control on worker's adherence to wear safety items 0.89
2. M3 : Safety regulations were not followed 0.88
3. M1 : Correct tools were not used for the specific task 0.83
4. M5 : No training program for the worker to implement the job 0.81
5. W6: Worker was not wearing personal protection items 0.80
6. W3: Worker was rushing the work 0.75
7. W4 : The accidents occurred due to misjudgment from the worker 0.75
8. M4: Safety items were not available on site 0.74
9. W7: Lack of knowledge by worker on wearing personal safety items 0.66
10. E2: Unsuitable living, housing and transportation facilities for the worker 0.62

11. J1: No enough rest times during the task

0.60

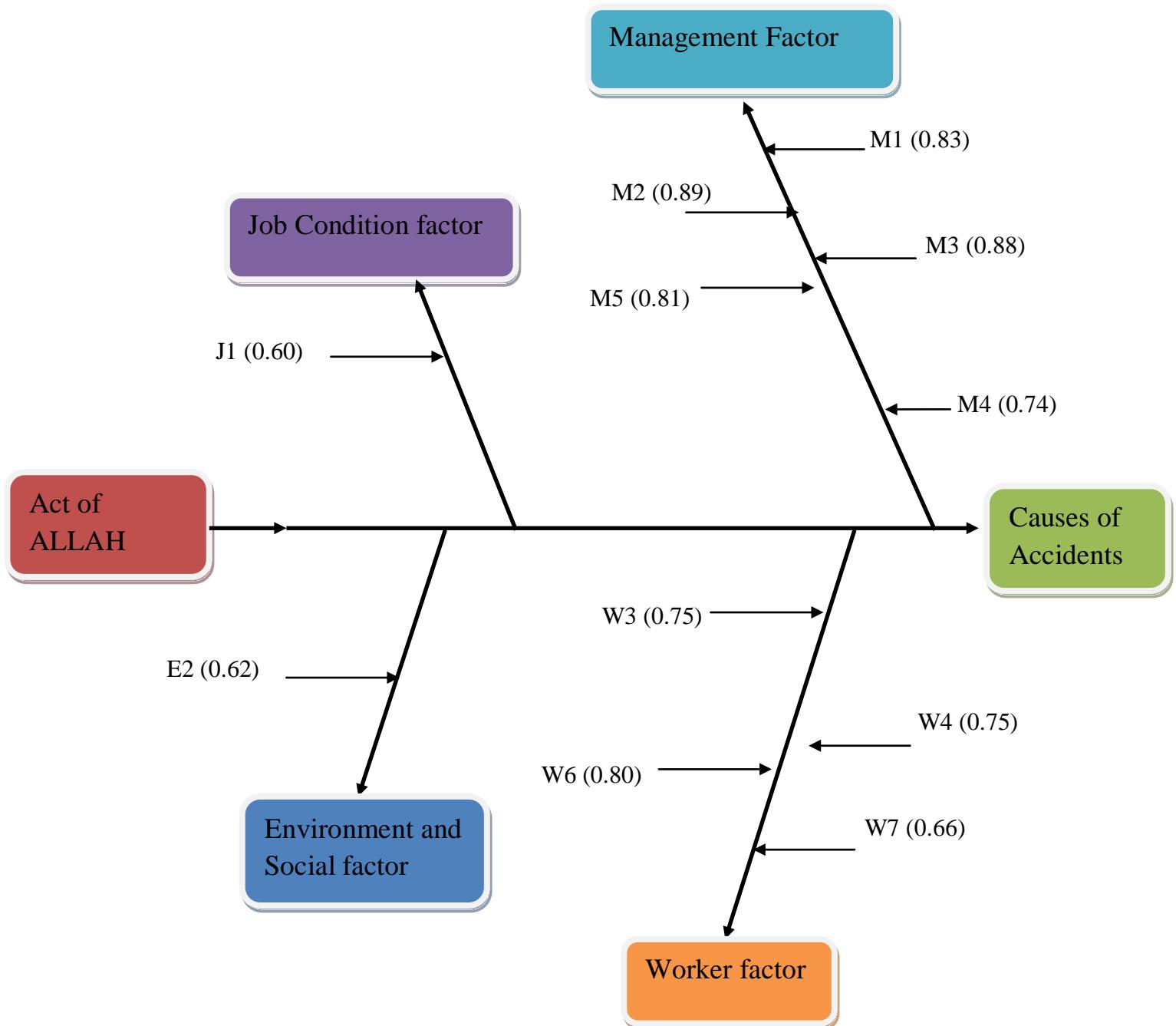


Figure 2 The top Factors Causes the Construction Accidents in Khartoum state, Researcher

Table2. The Ranking of Factors Contributing to Construction Accidents in Khartoum State

ACCIDENT FACTOR	High		Highly			RII	RANK		
	Disagree		Agree						
	(lowest effect)	Disagree	Neutral	Agree	(highest effect)				
	1	2	3	4	5				
M1: Correct tools were not used for the specific task	1	4	1	17	17	0.83	3		
M2: Lack of supervision and control on worker's adherence to wear safety items	0	1	2	15	22	0.89	1		
M3: Safety regulations were not followed.	0	1	4	14	21	0.88	2		
M4: Safety items were not available on site	2	8	3	14	13	0.74	7		
M5: No training program for the worker to implement the job	0	5	6	12	17	0.81	4		
W1: The worker was suffering from health problems	4	21	7	6	2	0.51	14		
W2: Physical fatigue caused the accident	1	17	9	9	4	0.59	11		
W3: Worker was rushing the work	0	7	7	16	10	0.75	6		
W4: The accidents occurred due to misjudgment from the worker	0	9	4	16	11	0.75	6		
W5: The worker had not enough sleeping hour	4	18	11	4	3	0.52	13		

W6: Worker was not wearing personal protection items	1	4	5	14	16	0.80	5
W7: Lack of knowledge by worker on wearing personal safety items	3	8	10	12	7	0.66	8
J1: No enough rest times during the task.	2	16	7	10	5	0.60	10
J2: Weather conditions were extreme	5	22	3	7	3	0.51	14
J3: Job or task was too difficult to perform	4	17	8	9	2	0.54	12
E1: No cohesiveness among job crew	3	18	9	8	2	0.54	12
E2: Unsuitable living, housing and transportation facilities for the worker	4	8	13	11	4	0.62	9

4.3 The Economic Impacts of Site Accidents in Construction Companies:

Analysis of the questionnaires showed that the loss of productivity was ranked as the highest economic impact with RII (0.85), disruption of current work (0.85), corrective actions to prevent re-occurrence of accident(0.85) and payments of injury or death claims (0.85)

Legal fees for defense against claims was ranked the second economic impact of site accident on construction companies with RII (0.81)

Increase of medical payments was ranked the third economic impact of site accident on construction companies with RII (0.80), The least ranked economic impact was expenditures on emergency equipment with RII (0.65)

Table 3 shows the ranking of the economic impacts of site accidents in construction companies.

Table3. The Ranking of the Economic Impacts of Site Accidents in Construction Companies

ECONOMIC IMPACT	High		Highly			RII RANK	
	Disagree		Agree				
	(lowest effect)		(highest effect)				
	1	2	3	4	5		
1. Loss of productivity	0	3	2	18	17	0.85 1	
2. Disruption of current work	0	2	2	20	16	0.85 1	
3. Training costs for new workers	0	6	4	19	11	0.77 5	
4. Damages to plant, equipment, completed work	0	6	5	17	12	0.78 4	
5. Corrective actions to prevent re-occurrence of accident	1	1	2	18	18	0.85 1	
6. Deterioration of the	1	13	5	8	13	0.70 7	

efficiency of the team	3	8	11	12	6	0.65	8
7. Expenditures on emergency equipment	3	8	11	12	6	0.65	8
8. Costs of workman's compensation insurance	2	6	3	14	15	0.77	5
9. Increase of Medical payments	0	6	1	21	12	0.80	3
10. Costs of rescue operations and equipment	0	6	3	20	11	0.78	4
11. Payments of injury or death claims	0	2	3	19	16	0.85	1
12. Legal fees for defense against claims	1	3	5	16	15	0.81	2
13. Increased insurance costs	1	5	9	14	11	0.75	6

4.4 The Insurance Policy toward the Workers in the Construction Companies in Khartoum State:

Figure 3 show that the insurance policy toward the workers in construction companies, Analysis of the questionnaires showed that (25%) have insurance policy toward the workers and (75%) doesn't have any insurance policy toward the workers.

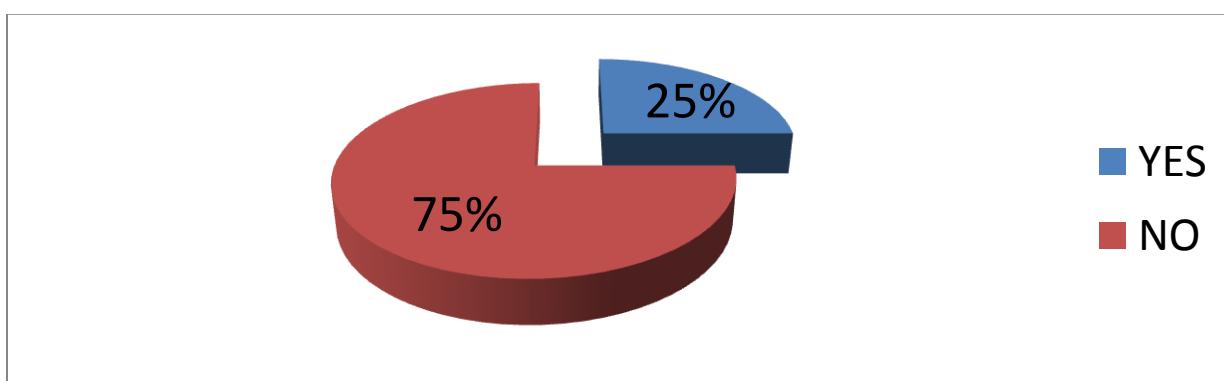


Figure 3 The insurance policy toward the workers in the construction companies in Khartoum state, Researcher

4.5 Companies have Department of Occupational Safety in Khartoum State:

Figure 4 show that the department of occupational safety in companies of Khartoum state, Analysis of the questionnaires showed that (20%) of construction companies have department of occupational safety and (80%) doesn't have.

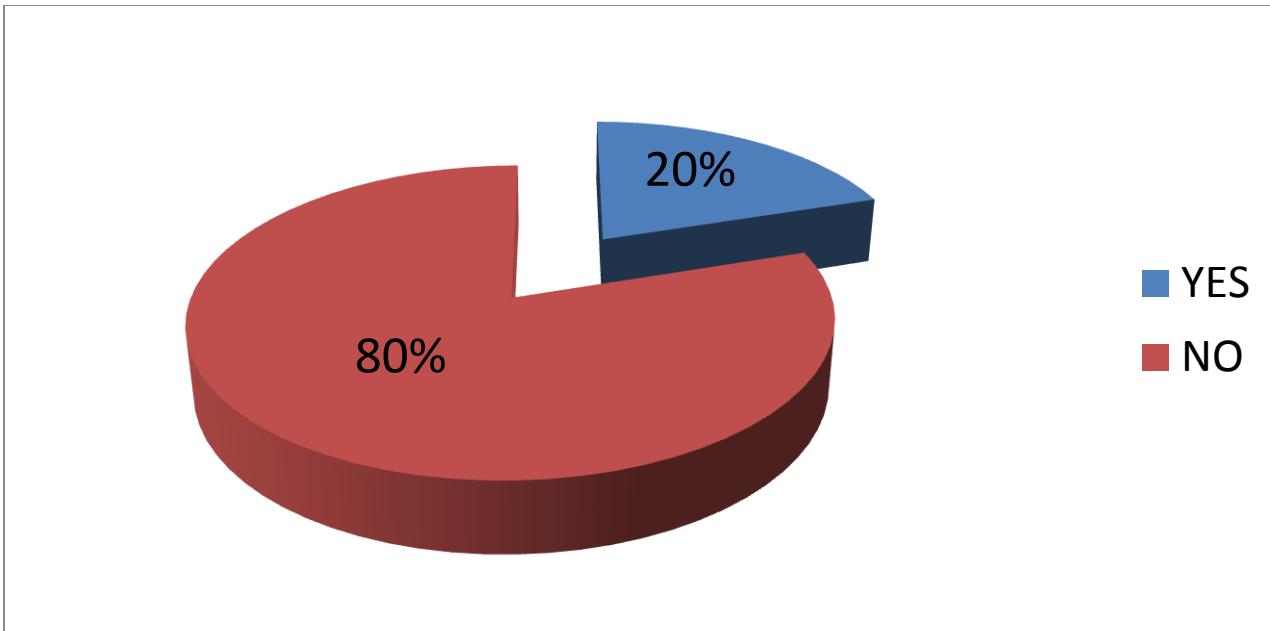


Figure 4 companies have department of occupational safety in Khartoum state, Researcher

4.6 The Safety Program in the Construction Companies in Khartoum State:

Figure 5 show that (28%) of the companies have safety program and (72%) doesn't have any safety program

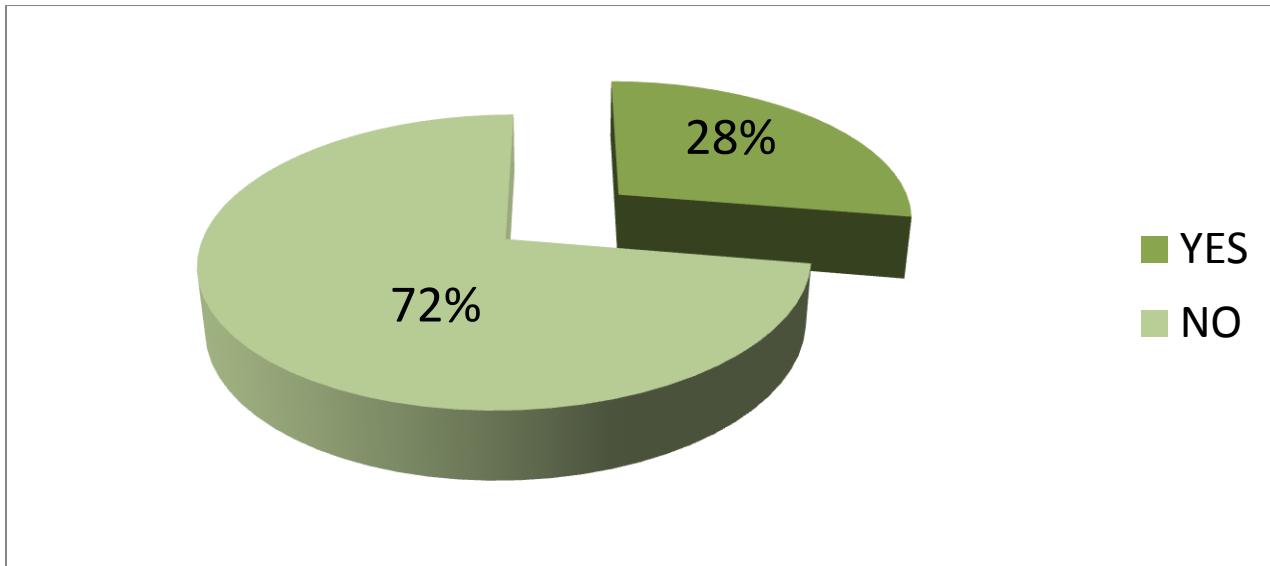


Figure 5 The safety program in the construction companies in Khartoum state, Researcher

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions:

The study was conducted in order to determine the construction accidents and their causes in construction sites in Khartoum state and to identify and quantify the economic impacts of site accidents on the construction companies, The following results were obtained:

- i. The construction industry has one of the highest accident rates if compared with other industries.
- ii. The most common accidents types in Khartoum state are Scaffolding accidents (70%), Fall from height accidents (67.5%), Tool accidents (60%), Falling object from height (50%) and Contact with electricity (40%).
- iii. The main causes of construction accidents in Khartoum state are related to management and worker factors, while the job condition and environment and social factors have no large effect.
- iv. The top causes that contributing to construction accidents in Khartoum state are: (1) Lack of supervision and control on worker's adherence to wear safety items; (2) Safety regulations were not followed ; (3) Correct tools were not used for the specific task; (4) No training program for the worker to implement the job; (5) Worker was not wearing personal protection items; (6) Worker was rushing the work; (7) The accidents occurred due to misjudgment from the worker;

(8) Safety items were not available on site; (9) Lack of knowledge by worker on wearing personal safety items; (10) Unsuitable living, housing and transportation facilities for the worker; (11) No enough rest times during the task.

- v. Site accidents have influential economic impacts on affected construction companies. The loss of productivity, disruption of current work, corrective actions to prevent re-occurrence of accident and payments of injury or death claims were ranked as the highest economic impacts.
- vi. (75%) of the construction companies doesn't have any insurance policy toward the workers.
- vii. (80%) of the construction companies doesn't have department of occupational safety.
- viii. (72%) of the construction companies doesn't have any safety program to his workers.

5.2 Recommendations:

The study therefore recommends that:

- i. The need to mainstream the principle of the use of personal protective tools such as safety boots, wearing of hand gloves and wearing of hard hats or helmet at anywhere on site and others, and to provide workers with equipment appropriate to the nature of the work and urged them to persuade them to use it and their usefulness.
- ii. Sort of machinery and leaving spaces and corridors between them to facilitate the movement of workers and materials at construction sites to reduce accidents
- iii. Preparing a separate law special for occupational safety, similar to other countries.
- iv. Taking into account the accidents at work and insurance policy toward the workers with the contractors (individual or company) when choosing a contractor in the tender stage.
- v. The need for a training and sensitize programs about the risks of the work environment and make sure the development of information and renewed it periodically in order to protect workers and to prevent them.
- vi. Damaged tools and equipment must be replaced, which may cause accidents in order to preserve the safety of the workers and the works in construction sites.
- vii. Putting a system of incentives for workers who apply occupational safety program.

5.3 Recommendations for Future Studies:

- i. Safety laws in Construction Contracts in Sudan.
- ii. Safety Management in Construction Projects in Sudan.
- iii. The Impact of the Costs of Accidents on Construction Projects.

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APPENDICES

English Questionnaire

I. Accidents and Company Information:

1. Type of accidents which suffered to company workers

Contact with electricity	<input type="checkbox"/>	Crane accidents	<input type="checkbox"/>	Gas explosion	<input type="checkbox"/>
Tool accidents	<input type="checkbox"/>	Exposure to fire	<input type="checkbox"/>	Structure failure	<input type="checkbox"/>
Fall from height	<input type="checkbox"/>	Exposure to hazardous material	<input type="checkbox"/>	Trench accidents	<input type="checkbox"/>
Fall from ladder	<input type="checkbox"/>	Slip/trip fall same level	<input type="checkbox"/>	Scaffolding	<input type="checkbox"/>
Natural causes	<input type="checkbox"/>	Falling object from height	<input type="checkbox"/>	Fall from roof opening	<input type="checkbox"/>
Machinery vehicle	<input type="checkbox"/>	Drowning	<input type="checkbox"/>	Asphyxiation	<input type="checkbox"/>

2. Does the company have any insurance policy toward the workers?

Yes No

3. Does the company have department of occupational safety?

Yes No

4. Is there a safety program in the company?

Yes No

II. The causes which led to accident occurred:

	Highly Agree	Agree	Neutral	Disagree	High Disagree
Correct tools were not used for the specific task					
Lack of supervision and control on worker's adherence to wear safety items					
Safety regulations were not followed					
Safety items were not available on site					
No training program for the worker to implement the job					
The worker was suffering from health problems					
Physical fatigue caused the accident					
Worker was rushing the work					
The accidents occurred due to misjudgment from the worker					
The worker had not enough sleeping hours					
Worker was not wearing personal protection items					
Lack of knowledge by worker on wearing personal safety items					
No cohesiveness among job crew					
No enough rest times during the task					
Weather conditions were extreme					
Unsuitable living, housing and transportation facilities for the worker					
Job or task was too difficult to perform					

III. The economic impact of site accidents on the construction companies:

	Highly Agree	Agree	Neutral	Disagree	High Disagree
Loss of productivity					
Disruption of current work					
Training costs for new workers					
Damages to plant, equipment, completed work					
Corrective actions to prevent re-occurrence of accident					
Deterioration of the efficiency of the team					
Expenditures on emergency equipment					
Costs of workman's compensation insurance					
Increase of Medical payments					
Costs of rescue operations and equipment					
Payments of injury or death claims					
Legal fees for defense against claims					
Increased insurance costs					

الاستبيان



جامعة السودان للعلوم والتكنولوجيا



كلية الدراسات العليا

مدرسة الهندسة المدنية

ماجستير إدارة التشييد

بحث تكميلي لنيل درجة الماجستير في إدارة التشييد

استبيان لغرض دراسة أنواع حوادث التشييد ومسبباتها في ولاية الخرطوم

I. معلومات الشركة وحوادث الموقع :

1/ نوع الحادث الذي تعرض له عمال الشركة :

<input type="checkbox"/>	حوادث إنفجارات الغاز	<input type="checkbox"/>	حوادث الروافع	<input type="checkbox"/>	حوادث التعامل مع الكهرباء
<input type="checkbox"/>	حوادث الانهيار	<input type="checkbox"/>	حوادث الحريق	<input type="checkbox"/>	حوادث أدوات التشييد
<input type="checkbox"/>	حوادث السقوط من الأماكن المرتفعة	<input type="checkbox"/>	حوادث التعرض للمواد الخطرة	<input type="checkbox"/>	حوادث السقوط من الاماكن المرتفعة
<input type="checkbox"/>	حوادث سقوط المواد والمعدات	<input type="checkbox"/>	حوادث سقوط الموارد	<input type="checkbox"/>	حوادث السقوط من سلام
<input type="checkbox"/>	حوادث الاختناق	<input type="checkbox"/>	حوادث الغرق	<input type="checkbox"/>	حوادث التعامل مع الماكينات
<input type="checkbox"/>	حوادث الأسباب الطبيعية (الغبار ، المطر ، الرياح)	<input type="checkbox"/>	حوادث السقالات	<input type="checkbox"/>	حوادث التصادم والانزلاق

2/ هل تقوم الشركة على تأمين عمالتها ؟

<input type="checkbox"/>	نعم	<input type="checkbox"/>	لا
--------------------------	-----	--------------------------	----

3/ هل يوجد قسم سلامة مهنية في الشركة ؟

<input type="checkbox"/>	نعم	<input type="checkbox"/>	لا
--------------------------	-----	--------------------------	----

4/ هل يوجد برنامج سلامة في الشركة ؟

<input type="checkbox"/>	نعم	<input type="checkbox"/>	لا
--------------------------	-----	--------------------------	----

II. الاسباب التي أدت الى وقوع الحادث:

لا أوافق بشدة	لا أوافق	محايد	أوافق	أوافق بشدة	
					الادوات المناسبة لم تستخدم في المهام المحددة
					عدم وجود الاشراف والرقابة على العاملين من حيث إرتداء أدوات السلامة
					عدم اتباع قواعد السلامة
					ادوات السلامة لم تكن متوفرة في الموقع
					لاتوجد برامج تدريبية للعمال لتنفيذ الاعمال
					العامل يعاني من مشاكل صحية
					الارهاق البدني هو السبب في الحادث
					التسرع والتعجل في اداء العمل
					وقع الحادث بسبب سوء التقدير من العامل
					لم يحصل العامل على قسط كافي من الراحة والنوم
					العامل لم يرتدي معدات الوقاية الشخصية
					قلة المعرفة لدى العامل بطريقة ارتداء معدات السلامة الشخصية
					لا يوجد انسجام وتماسك بين افراد طاقم العمل
					السكن والمواصلات والمعيشة غير مناسبة للعامل .
					لا يوجد وقت راحة كافي خلال أداء المهمة .
					كانت الظروف الجوية قاسية
					صعوبة تنفيذ العمل

III. التأثير الاقتصادي للحوادث على شركات التشييد:

لا أوافق بشدة	لا أوافق	محايد	أوافق	أوافق بشدة	
					يؤدي الحادث إلى خفض الانتاجية
					اضطرابات في إنجاز العمل
					تكليف إضافية في تدريب العمال البديل أو الجدد
					الاضرار التي تلحق بالأجهزة و المعدات والأعمال المنجزة
					الإجراءات التصحيحية لمنع تكرار الحادث
					تدهور كفاءة فريق العمل بسبب الحادث
					الإنفاق الزائد على معدات الطوارئ
					تكليف تأمين العمال المصابين
					زيادة المصاريف الطبية
					تكليف عمليات الإنقاذ
					دفعيات مطالبات تعويض اصابات العمل والحوادث
					الاتعاب القانونية ضد الدفاع عن المطالبات
					زيادة تكاليف التأمين