

# **CHAPTER ONE**

## **1. Introduction**

### **1.1 General**

Construction equipment is one of the three major inputs of the building construction process, together with labors and materials. One of the development and use of equipment with construction is, to enable construction activities to be performed which are beyond the limit of human strength, and to achieve high standards, which is required by current construction technologies and design . The second one is to make the construction process more economics .

Construction of projects requires heavy equipment or “big iron” to assist many of the work activities. At the start of the 21st century, construction accounted for approximately 10% of the U.S. gross national product and employed approximately 4.5 million people. Heavy construction equipment is one of the primary reasons that construction has reached this status. In fact, the role of heavy construction equipment today is mission critical and indirectly influences the quality of our lives everyday. Heavy construction work typically requires high-volume or high-capacity equipment. These requirements are typically driven by the large amount of work to be done and the amount of time to complete it. This work can further be classified by whether the construction is vertical or horizontal. Vertical construction typically requires less surface work, earth moving, and excavating and more lifting. Horizontal construction typically requires more surface work and limited lifting.

Today contractors undertake many types of construction activities that require different types, sizes, and groupings of equipment for earth moving, excavating, and lifting. There is a piece of equipment for practically any work activity, large or small. Construction equipment today is specifically designed by the manufacturer to perform certain mechanical operations that accomplish a work activity. <sup>[1]</sup>

## **1.2 Problem of research**

From the field survey for construction projects in Khartoum state, the researcher found that construction equipment is a major input of building construction and it have an impact in construction industry beside that low level of training employment for equipment and hand tools require in some work . All those reasons impact in productivity time of projects and quality.

## **1.3 Important of research**

Try to identify the equipment that help to increase productivity in the construction projects and the implications of the use of modern equipment with good management in construction projects.

## **1.4 Hypotheses of research**

- 1/ The heavy equipment have a significant impact in the construction.
- 2/ Use of equipment needs employment training consistent with his work.
- 3/ Required the use of a hand tools in some work.

## **1.5 Objective of research**

The aim of research is

- 1/ To identify the types of equipment that is used in the site.
- 2/ To comparison between the hand tools and heavy equipment in the site.
- 3/ To identify the Factors that help to increase equipments production .

## **1.6 Methodology of research**

Use descriptive analytical method that study construction equipment for the purpose of the study. Through data collection and using Statistical Package of Social Sciences (SPSS) statistically test the validity of hypotheses. Researcher visited the site engineering, library and website to design questionnaire from data and hypotheses.

## **1.7 Research layout**

The research includes five chapters. Chapter one, the introduction of the research (general of construction equipment, the problem, Important, Hypotheses, Objective, Methodology, layout). In the second chapter, types of construction equipment divide to hand tools and heavy equipment and their using in the construction project, the factors that help to increase equipment production. In the third chapter, the methodology of study using descriptive analytical method that study construction equipment (design of questionnaire, society and the research sample, duration of study, data collection technique, data management and analysis). In the fourth chapter, the result and discussion for analysis of questionnaire of the study shown in Tables and Figure's. In the fifth chapter, the conclusion and recommendation of the study.

## CHAPTER TWO

### 2.Literature review

#### 2.1.The Construction Equipment

Equipment are use for highway projects, irrigation, buildings, power projects etc. Equipment is a critical resource in the execution of most construction projects 15-30% of total project cost has been accounted towards equipment and machinery.

Today's building construction projects are highly mechanized. With the growing industrialization of construction and the gradual shift to offsite prefabrication of structural and finishing elements that are then assembled (rather than produced) on site, production equipment is increasingly making room for *transportation* equipment. Thus, material handling and lifting equipment dominates construction sites as an essential resource, constituting a major part of the project's construction cost.

The typical concrete-construction building site will employ several or all of the following equipment types: (1) cranes, (2) material handlers, (3) concrete pumps, (4) hoists and lifts, and (5) forming systems.

Concrete is commonly produced on-site only in the case of large projects requiring high concrete volumes or transportation distances that are too great for the supply of ready-mixed concrete. Earthmoving equipment is used for the initial, substructure phase of construction and often during final landscape development work but is hardly seen on the jobsite throughout construction of the structure itself (unless construction progress at various parts of the project is sequenced such that one part of the project is already above ground while another may still be under ground).

Equipment offered and used for building construction has seen other changes in recent years. Most notable is the abundance of telescopic machines used for moving materials and workers about the jobsite. Modern telehandler now replace the traditional forklifts. Coming with a variety of front-end attachments, these machines are gradually taking over other equipment as well, such as backhoe-loaders and small rough-terrain mobile cranes. Telescopic aerial work platforms and scissor-type lifts are often used on works for which conventional scaffolds commonly had to be erected. Sometimes a great number of these and other light, versatile, and mobile units may be seen on just one construction site. [2]

## **2.2 Importance of Tools and Equipment**

Equipping the construction site with the correct tools and equipment plays an essential role in achieving timely and good quality results. For every construction activity there is an optimal combination of tools, equipment and labor. Depending on the nature and content of the works, the technical staff needs to know which tools to use and how to effectively combine them with manual labor.

Once on site, equipment requires trained operators and supervisory staff who are proficient in its operation and maintenance. Faulty equipment is a common reason for delays on construction sites. A major responsibility of the project management is to ensure that tools and equipment are maintained in a good condition and are readily available when required for the various work activities. When applying labor-based work methods, the use of hand tools supported with selected items of light equipment can produce results comparable with those achieved when using only heavy equipment. For every construction activity there is an optimum combination

of equipment and labor. In order to utilize the equipment and labor in the most effective way, the use of equipment needs to be carefully coordinated with the output of the work gangs. For certain construction activities, particularly hauling of materials and compaction, high labor productivity and good quality of work may be difficult to achieve using only manual. [3]

### **2.3. Hand Tools**

Hand tools are the main instruments used by the workers to carry out the activities involved in building a road using labor-based work methods. It is therefore important that project staff know how to select and maintain the tools since they have a significant influence on the work outputs.

Ergonomically efficient hand tools are comfortable to use, well adapted to particular construction tasks and suit the physical characteristics of the workers. Ergonomically efficient tools and correct working techniques allow the workers to use the major body muscles effectively and make the most productive use of their energy. The proper use of suitable tools will also prevent injuries on site. labor and hand tools. In such cases, using light construction equipment can increase the efficiency of work. Site supervisors need to know how to use the tools and how to operate the equipment in order to secure good work progress and the expected high quality results. It is also important that staff know the full potential, as well as the limitation, of the use of manual and equipment-based works methods. Finally, tools and equipment need regular maintenance, requiring good workshop facilities, a reliable supply of spare parts and qualified mechanical staff. [3]

Hand tools should be of good quality and designed so that they are efficient in use. The tools should be strong enough to withstand intensive use at the work site, and resistant to wear so that they have a long working

life. For most tools this means that the metal head should be made from carbon steel, heat-treated to give the correct strength and wear characteristics. For the main excavation and striking tools such as hoes, pickaxes, mattocks and sledgehammers, the tool heads should be forged in a single piece. Cast or fabricated and welded tool heads do not provide sufficient quality. The timber handle should be made from a tough, preferably light, seasoned hardwood. The wood should be straight grained, with the grain lying along the length of the handle. The handles should not have any splits or knots, since these lead to handles breaking when used.

Tool handles should be smoothly finished and carefully shaped with a raised grip at the end to prevent the workers hands sliding off. Long handled tools are generally preferred since they allow the workers to stand in an upright position, which is less tiring than having to bend or crouch down. The handle should be a tight, secure fit in the head of the tool. Good quality tools are inevitably more expensive than poor quality tools. However, it is wrong simply to purchase the cheapest tools available. This will only result in problems on site and the need for the frequent replacement of broken tools. Efficient hand tools allow workers to achieve the maximum productivity from their efforts. Efficient tool heads should:

- 1/ Have the correct shape in order to work efficiently.
- 2/ Be of suitable weight for the strength of the workers.
- 3/ Be properly sharpened along the working edges.

It is possible to obtain good quality, efficient tools manufactured locally. Before extensive purchases of tools are made, their cost, strength, durability and design should be carefully evaluated. The optimal choice of tools also varies from place to place, depending on the site conditions, type of works carried out, type of soils and local skills and practice. Site supervisory staff

needs to be trained in the proper use and maintenance of tools. Since the labour is temporarily employed, they are not provided with any formal training in the use of hand tools. However, the supervisors are responsible for instructing the workers and ensuring that tools are properly used and maintained.

The workers are often very conservative concerning the use of hand tools. Local traditions may create some reluctance among workers to use new tools. When new tools are introduced, it is important to provide adequate instruction in their proper use. It is also worthwhile to assess the effectiveness of the new tools as compared to the local traditional work methods. [3]

The main types of hand tools are hoes, Pickaxes and mattocks, shovels , crowbars, rakes and spreaders, wheelbarrows.

### **2.3.1 Hoes**

The hoe used when using labor-based work methods for rural road works as shown in Fig. (2-1). It can be used for excavating soft soils and is often used in combination with stretchers or head baskets. Hoes are also effective when excavating drains, cutting back slopes and removing topsoil. The most efficient way of using the hoe is when the workers can stand slightly below the level being excavated. As it is commonly found and used in farming communities, its use is well known among the workers and would normally not need any instruction in how it is effectively used.



**Fig. (2-1): Typical hoe**

### **2.3.2 Pickaxes and Mattocks:-**

Pickaxes and mattocks are tools used for excavating hard or stony soils, difficult to penetrate with hoes as shown in Fig. (2-2). Pickaxes are effective when breaking hard or stony ground. When excavating side drains in hard soils, the pickaxe is particularly effective. Mattocks are useful for shaping slopes in hard soils, and also to cut roots. Make sure whoever is operating a pickaxe has sufficient space to operate by ensuring that all other workers are at a safe distance. Both these tools always come with an oval shaped eye so that the handle .



**Fig. (2-2): Typical Pickaxes and Mattocks**

### **2.3.3 Shovels**

Shovels are used for scooping up material and loading it on to a trailer, truck or wheelbarrow, or throwing it directly to where the material is needed as shown in Fig. (2-3) . The shovel has a rounded or pointed blade making it suitable for both digging and loading purposes. The advantage of

using shovels is mainly related to their effectiveness when loading or throwing materials. A good example in this respect is when excavating side drains. Workers equipped with shovels can then throw the excavated materials from the drain directly onto the road surface, which is then used to form the camber



**Fig (2-3) Typical Shovel**

#### **2.3.4 Crowbars**

The crowbar, like the pickaxe, is mostly used for penetrating or breaking up stony or hard soils. It is also used for moving boulders or heavy items, by using it as a lever. The crowbar needs to be made from high-grade steel so that it does not bend easily. Crowbars are usually manufactured either as round or octagonal section rods. For infrastructure work, a diameter of 30mm provides a good and firm grip. The length should be from 1.5 to 1.8metres . With these dimensions, the crowbar gains sufficient weight to penetrate hard and compact soils and allows the worker to stand up right when operating it. The bar can be fitted with a pointed or a chisel end – or both. The pointed end is used to penetrate and break loose material, while the chisel end is more useful for leverage.

### **2.3.5 Rakes and Spreaders**

Rakes are used in road works for raking out vegetation from loose soil. Commercially produced rakes have 10 to 16 teeth, each about 75 - 100mm long, with an overall length about 400 - 450mm.

Spreaders are useful when forming the camber and when spreading gravel. Spreaders are made of sheet metal (2-3 mm thick) with ridges on one side, which are used to level the road surface according to set levels and gradients. The handles for both tools should be long enough to allow the worker to operate comfortably in a standing position.

### **2.3.6 Wheelbarrows**

The wheelbarrow is a useful piece of transport equipment for short distances (up to 200 meters) as shown in Fig. (2-4). Wheelbarrows are used for earth and concrete works, transporting construction materials such as soil, gravel, sand, aggregate, stone, concrete, etc. Wheelbarrows are made in many different types and qualities. A good wheelbarrow should be able to take a big load (struck capacity approximately 60 to 70 liters) and be easy to balance and tip. Wheelbarrows are used to transport materials over short distances. If the ground is soft or very stony, planks should be laid to provide a smooth and firm running surface. The use of planks is also good for helping wheelbarrows up steep sections. When using several wheelbarrows, the best performance is achieved when the hauling route is organized as one-way runs. Assigning a separate route for hauling the material to the dumping location and returning empty by a different route avoids any traffic congestion. [3] [4]



**Fig. (2-4) Typical Wheelbarrows**

The main types of heavy construction equipment are earth moving equipment, construction vehicles, and material handling equipments. [5]

#### **2.4.Earth moving equipment**

Earthmoving equipment is used in the construction industry to:

- Shift large amounts of earth,
- Dig foundations and landscape areas.

The house sits atop an undercarriage with tracks or wheels. Excavators are also called diggers.

Excavators are used in many ways:

- 1.Digging of trenches, holes, foundations
- 2.Material handling
- 3.Brush cutting with hydraulic attachments
- 4.Forestry work
- 5.Demolition
- 6.General grading/landscaping
- 7.Heavy lift, e.g. lifting and placing of pipes
- 8.Mining, especially, but not only open-pit mining
- 9.River dredging

#### 10. Driving piles, in conjunction with a pile driver

Types of earthmoving equipment include hydraulic excavators, bulldozers, compressors and loaders. Excavators are heavy construction equipment consisting of a boom, stick, bucket and cab on a rotating platform known as the "house". The types of earthmoving equipments are loader, skidloader, grader, crawler loader, backhoes, bulldozers, trachers, scrapers and wheeled loading shovels.

##### 2.4.1 Loader:-

A **loader** is a heavy equipment machine as shown in Fig. (2-5). It's often used in construction, primarily used to load material (such as asphalt, demolition debris, dirt, snow, feed, gravel, logs, raw minerals, recycled material, rock, sand, and woodchips) into or onto another type of machinery (such as a dump truck, conveyor belt, feed-hopper, or railcar).



**Fig. (2-5) Typical type of Loader**

### **2.4.2 Skid loader or skid-steer loader**

A skid loader or skid-steer loader is a small rigid frame, engine-powered machine with lift arms used to attach a wide variety of labor-saving tools or attachments as shown in Fig.(2-6) . Though sometimes they are equipped with tracks, skid-steer loaders are typically four-wheel vehicles with the wheels mechanically locked in synchronization on each side, and the left-side drive wheels can be driven independently of the right-side drive wheels.



**Fig.(2-6): Typical type of skid loader or skid-steer loader**

### **2.4.3 Graders**

A grader, also commonly referred to as a road grader, a blade, a maintainer, or a motor grader, is a construction machine with a long blade used to create a flat surface is shown in Fig. (2-7). Typical models have three axles, with the engine and cab situated above the rear axles at one end of the vehicle and a third axle at the front end of the vehicle, with the blade in between. In civil engineering, the grader's purpose is to finish grade (refine, set precisely) the rough grading performed by heavy equipment or engineering vehicles such as scrapers and bulldozers. Graders are

commonly used in the construction and maintenance of dirt roads and gravel roads. In the construction of paved roads they are used to prepare the base course to create a wide flat surface for the asphalt to be placed on. Graders are also used to set native soil foundation pads to finish grade prior to the construction of large buildings.



**Fig.(2-7) Typical type of Grader**

#### **2.4.4. Crawler loader**

The crawler loader combines the stability of the crawler tractor with the abilities of a wheel loader shown in Fig. (2-8). However, to construct a reliable crawler loader it requires more than simply attaching a loader bucket onto a crawler tractor. It must be designed with its specific purpose in mind to ensure it has the strength to withstand heavy excavating. The introduction of hydraulic excavators diminished the market for the crawler loader because it was unable to match the excavator's lifting power and flexibility. However, crawler loaders are capable of maneuvering across the entire construction site under its own power, whereas most hydraulic excavators require towing or transport. While crawler tractors are still being

manufactured today for niche markets, they reached their peak of popularity in the 1960s.



**Fig.(2-8): Typical type of crawler loader**

#### **2.4.5.Backhoe**

A backhoe, also called a rear actor or back actor, is a piece of excavating equipment or digger consisting of a digging bucket on the end of a two-part articulated arm as shown in Fig.(2-9). They are typically mounted on the back of a tractor or front loader.



**Fig.(2-9): Typical type of Backhoe**

#### **2.4.6. Bulldozer**

A bulldozer is a crawler (continuous tracked tractor) equipped with a substantial metal plate (known as a blade) as shown in Fig.( 2-10) used to push large quantities of soil, sand, rubble, or other such material during construction or conversion work and typically equipped at the rear with a claw-like device (known as a ripper) to loosen densely-compacted materials.



**Fig.(2-10): Typical type of Bulldozer**

#### **2.4.7. Trencher**

Trenchers, or ditchers as they are sometimes called are similar to excavators in the sense that they penetrate the earth, breaking soil and rock, and remove it from the ground as shown in Fig. (2-11). They differ from excavators in that the soil is removed in one continuous movement. Trenchers are specifically used for digging trenches for pipes, but other machines have been improvised in the past to serve this purpose. Trenchers can come in two types: ladder trenchers and wheel trenchers, and can dig trenches at speeds that other machines cannot compare to.



**Fig.(2-11): Typical type of Trencher.**

#### **2.4.8. Scraper**

In civil engineering, a wheel tractor-scraper is a piece of heavy equipment used for earthmoving as shown in Fig.( 2-12). The rear part has a vertically moveable hopper (also known as the bowl) with a sharp horizontal front edge. The hopper can be hydraulically lowered and raised. When the hopper is lowered, the front edge cuts into the soil or clay like a plane and fills the hopper.



**Fig.(2-12): Typical type of Scraper.**

### **2.4.9wheeled loading shovels**

A power shovel (also stripping shovel or front shovel or electric mining shovel) is a bucket-equipped machine as shown in Fig.(2-13), usually electrically powered, used for digging and loading earth or fragmented rock and for mineral extraction. Power shovels are used principally for excavation and removal of overburden in open-cut mining operations, though it may include loading of minerals, such as coal. They are the modern equivalent of steam shovels, and operate in a similar fashion.



**Fig.(2-13): Typical type of wheeled loading shovel**

## **2.5 Construction vehicles**

Engineering or Construction vehicles are heavy-duty vehicles, specially designed for executing construction (Civil engineering) tasks, most frequently, ones involving earth moving.<sup>[5],[6],[7]</sup>

### **2.5.1.Dumper**

A dumper is a vehicle designed for carrying bulk material often on building sites as shown in Fig. (2-14). Dumpers are distinguished from dump trucks by configuration: a dumper is usually an open 4-wheeled vehicle with the load skip in front of the driver, while a dump truck has its cab in front of the load. The skip can tip to dump the load; this is where the name "dumper" comes from. They are normally diesel powered. A towing eye is fitted for secondary use as a site tractor. Modern dumpers have payloads of up to 10 tones and usually steer by articulating at the middle of the chassis



**Fig.(2-14): Typical type of Dumper**

### **2.5.2. Tippers**

A truck or lorry the rear platform of which can be raised at the front end to enable the load to be discharged by gravity also called tip truck as shown in Fig. (2-15).

Tippers are suited for the rough and tumble of mining & quarrying operations, as well as for carrying bulk loads in construction and infrastructure industries. Complete maneuverability, high performance and long-term endurance are common to all trucks, resulting in lower operating costs.



**Fig.(2-15) : Typical type of Tipper**

## **2.6. Material handling equipment**

The main type are

### **2.6.1.Crane**

A crane is a type of machine, generally equipped with a hoist, wire ropes or chains and sheaves as shown in Fig. (2-16). That can be used both to lift and lower materials and to move them horizontally. It is mainly used for lifting heavy things and transporting them to other places.



**Fig.(2-16): Typical type of Crane**

### **2.6.2.Hoists**

A hoist is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps as shown in Fig (2-17). It may be manually operated, electrically or pneumatically driven and may use chain, fiber or wire rope as its lifting medium. The load is attached to the hoist by means of a lifting hook. Also known as a Man-Lift, Buck hoist, temporary elevator, builder hoist, passenger hoist or construction elevator, this type of hoist is commonly used on large scale construction projects, such as high-rise buildings or major hospitals. There are many other uses for the construction elevator . Many other industries use the buck hoist for full time operations. The purpose is being to carry personnel, materials, and equipment quickly between the ground and higher floors, or between floors in the middle of a structure.



**Fig. (2-17:Typical type of Hoist**

## **2.7 Other equipment**

### **2.7.1. Concrete mixer**

A concrete mixer (also commonly called a cement mixer) is a device that homogeneously combines cement, aggregate such as sand or gravel, and water to form concrete as shown in Fig. (2-18). A typical concrete mixer uses a revolving drum to mix the components. For smaller volume works portable concrete mixers are often used so that the concrete can be made at the construction site, giving the workers ample time to use the concrete before it hardens. Special concrete transport trucks (in-transit mixers) are made to transport and mix concrete up to the construction site. They can be charged with dry materials and water, with the mixing occurring during transport. With this process, the material has already been mixing. The concrete mixing transport truck maintains the material's liquid state through agitation, or turning of the drum, until delivery.



**Fig.(2-18) : Typical type of Concrete mixer**

### **2.7.2. Compactor**

A compactor is a machine or mechanism used to reduce the size of waste material or soil through compaction as shown in Fig.( 2-19). In construction, there are three main types of compactor: the plate compactor, the Jumping Jack and the road roller. The roller type compactors are used for compacting crushed rock as the base layer underneath concrete or stone foundations or slabs.



**Fig.(2-19):Typical type of Compactor**

### 2.7.3.Paver

A paver (paver finisher, asphalt finisher, paving machine) is an engineering vehicle as shown in Fig.( 2-20) used to lay asphalt on roadways. It is normally fed by a dump truck. A separate machine, a roller, is then used to press the hot asphalt mix, resulting a smooth, even surface. The sub-base being prepared by use of a grader to trim crushed stone to profile after rolling.



**Fig.(2-20): Typical type of Paver**

### 2.7.3. Plastering machines

- **Worm-drive pump**

Most commonly, sprayers have a worm-drive pump that pumps the plaster up to a spray gun that has a large nozzle as shown in Fig.( 2-21), usually 4 to 8 mm, that extrudes the plaster into a chamber on the end of the gun .



**Fig.(2-21) : Typical type of Worm-drive pump**

- **Piston pump**

Newer types of plaster sprayer have a piston pump, which has sufficient pressure to spray smooth (un textured) plaster without compressed air as shown in fig. (2-22).



**Fig.(2-22):Typical type of Piston pump**

#### **2.7.4. Road roller**

A road roller (sometimes called a roller-compactor, or just roller) is a compactor type engineering vehicle as shown in Fig (2-23) used to compact soil, gravel, concrete, or asphalt in the construction of roads and foundations, similar rollers are used also at landfills or in agriculture.



**Fig.(2-23) : Typical type of Road roller**

## **2.8.Production rate for modern equipment**

Table shows production rate:

| <b>Item</b> | <b>Equipment</b> | <b>Description</b>                 | <b>Production rate</b>       |
|-------------|------------------|------------------------------------|------------------------------|
| 1           | Loader           | Mechanic backfilling               | 200 m <sup>3</sup> /day      |
| 2           | Crawler loader   | Compromise work                    | 450 m <sup>3</sup> /day      |
| 3           | Grader           | Compromise work                    | 150m <sup>3</sup> /hour      |
| 4           | Backhoe          | Excavation for sandy soil          | 300m <sup>3</sup> /day       |
|             |                  | Excavation for soil                | 150m <sup>3</sup> /day       |
|             |                  | Excavation for soil                | 120m <sup>3</sup> /day       |
|             |                  | Excavation for soil                | 15 m <sup>3</sup> /day       |
| 5           | Bulldozer        | Mechanic backfilling               | 400m <sup>3</sup> /day       |
| 6           | Tippers          | Mechanic excavation for sandy soil | 150m <sup>3</sup> /day       |
|             |                  | Mechanic excavation                | 75m <sup>3</sup> /day        |
|             |                  | Mechanic excavation                | 60m <sup>3</sup> /day        |
|             |                  | Mechanic excavation                | 7.5m <sup>3</sup> /day       |
| 7           | Concert mixer    | Mechanic                           | 100m <sup>3</sup> /day       |
|             |                  | Manually                           | 40m <sup>3</sup> /day        |
| 8           | Road loader      | Compromise work                    | 115m <sup>3</sup> /day       |
| 9           | paver            | Road work                          | 700 m <sup>3</sup> /day      |
|             |                  | Road work                          | 1500-3000m <sup>3</sup> /day |

## **2.9 Factors that help to increase equipment production**

The main factors that help to increase equipment production are

- 1- Training worker for equipment.
- 2- Construction Equipment Management.

### **2.9.1. Training worker for equipment:-**

The best safety training in the world cannot overcome poorly designed or poorly maintained equipment and tools. If a piece of equipment is unsafe by design and the only option then appropriate steps must be taken to identify those potential hazards. An example, it that a worker can innocently place their hand and fingers under a vacuum beater bar to test its not being jammed. The danger is that they can lose a finger or nail or suffer burns from the fast moving brush and parts. Simply training workers to always turn off and unplug a machine before trying to conduct any maintenance. The best case is for the worker to be trained to ask the supervisor or maintenance staff to check out the equipment or give them a replacement unit.

All people using equipment at work must be adequately trained to ensure health and safety in its use, supervision or management. Some work activities require detailed formal training but, for most everyday activities involving work equipment, adequate training can be delivered in-house using the manufacturer's instructions and the background knowledge / skills of more experienced workers and managers.

People should be competent for the work they undertake. Training – along with knowledge, experience and skill– helps develop such competence. However, competence may (in some cases) necessarily include medical fitness and physical / mental aptitude for the activity.

Engineers must ensure that all persons who use work equipment have received adequate training for the purposes of health and safety, including training in the methods which may be adopted when using work equipment, and risks which such use may entail and the precautions to be taken. There is a similar duty to ensure adequate training in relation to supervisory and managerial staff.

It is not possible to detail here what constitutes adequate training as requirements will vary **according to**:

- The job or activity
- The existing competence of workers
- The circumstances of the work (e.g. degree of supervision)
- The work equipment.

The training standard required should be adequate in ensuring the health and safety of your workers and any people who may be affected by the work, so far as reasonably practicable.

All those providing training on the use of any work equipment should be sufficiently skilled and competent. The degree of skill, knowledge and competence to do so will depend on many factors, including the nature of the work equipment and the risks it poses.

Engineers will need to establish what training is appropriate in each particular circumstance; for example the relevant trade association may be able to advise and have training schemes in place for some work activities. For many areas, industry-recognized, externally-provided training on the use of work equipment.

However, as long as training is provided competently and to the standard necessary to ensure health and safety, there is no bar to training being given by competent in-house staff. In these cases, it is desirable that

those providing the training have some skill and aptitude to undertake training, with sufficient industrial experience and knowledge of the working environment to put their instruction in context. They should also have the ability to assess the skills attained.

Training and the techniques used can vary and may include (as appropriate to the risk, complexity of the task, equipment and existing competence of staff):

- Self-study, e.g. reading manufacturer's instructions
- Simple in-house instruction and demonstration with supervision
- Formal in-house training, provided by competent, qualified or experienced staff – often coupled with some form of documented competence assessment
- Externally provided training (usually with a competence assessment), provided by competent, suitably qualified people

All people using work equipment or supervising / managing its use should be sufficiently competent to do so safely. Competence may include in some cases, minimum medical fitness (e.g. for driving vehicles) and either or both physical and mental aptitude (e.g. the ability to climb and work at height to operate a tower crane), as well as knowledge and skill. 'Competence' is not defined although, for some work tasks (such as woodworking and operating) there are minimum training requirements which will assist in gaining sufficient competence to undertake tasks safely and without risk to health. [8]

### **2.9.2. Construction Equipment Management**

Good project management in construction must vigorously pursue the efficient utilization of labor, material and equipment. The use of new

equipment and innovative methods has made possible wholesale changes in construction technologies in recent decades. The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job-site productivity of a project. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction. [8]

The Stages of the building construction process of the equipment management are :

- 1/ Ownership cost of equipment;
- 2/ The selection of construction equipment;
- 3/ Controlling the equipment management during building construction period;
- 4/ The planning process for equipment and methods;

### **1/ Ownership cost of equipment**

Knowledge about owning cost and operating cost is must before equipment mobilization. Also, monitoring of actual operating and owning cost of equipment on regular basis is necessary for optimum profitability.

Also, monitoring of actual operating and owning cost of equipment on regular basis is necessary for optimum profitability. Owning cost and operating cost of equipment has significant impact on profitability of work executed. Owning and operating cost, need to be calculated based on the financial investment terms and condition, depreciation method and operating condition of equipment. The ownership costs of construction plant and equipment can be categorized into:-

### **(i) Fixed Cost**

Fixed costs are those which can be predetermined as accumulating with the passage of time, rather than with the rate of work. Need to pay these costs regardless of whether the equipment is used or not. Fixed costs of equipment are the result of procurement and vanish when it is sold.

- Commonly included in fixed costs are : equipment depreciation, interest on investment , taxes, storage and protection, insurance.

### **2. Variable cost**

Variable costs incurred only when the machine is put to work. These costs include the costs of fuel, lubricants, wear parts, equipment maintenance and repairs. Operating cost depends largely on the way machine is operated (operator skill). Proper maintenance also play's vital role in operating cost.

Variable costs incurred only when the machine is put to work. These costs include the costs of fuel , lubricants, lubricants, wear parts, equipment maintenance and repairs.

Operating cost depends largely on the way machine is operated (operator skill).Proper maintenance also play's vital role in operating cost.<sup>[10]</sup>

### **2 /The selection of construction equipment**

Proper selection of equipment for construction project is of vital importance for its speedy and economical completion. Problem of equipment selection has become more complicated, because large variety of equipment are being manufactured now-a-days. For selection of equipment, a considerable experience in the operation and maintenance in the field is essential. Records kept for operation, maintenance and actual output obtained under comparable conditions of previous projects will greatly help in taking decision for equipment selection. With the undertaking of new projects and the retirement of old machinery and

equipment, it becomes necessary to acquire new construction equipment. . It is also important to determine what sort of equipment and capacity is needed. In fact, selection of equipment for the project is one of the key decisions in planning and executing a construction project, which affects how the work will be done, the time required to complete the work, and the cost that will be accrued. Generally, an equipment manager is responsible of selecting the equipment, whereas it is the responsibility of the construction planning group to select equipment. Nevertheless, both the inventory of equipment in hand and the standard equipment policy play an important role in equipment selection. Therefore, final decision on the equipment required for the projects is generally given by equipment managers, project managers, and construction planning group together. Often, the decision making process can create tensions in the firm. Once the selection of equipment is made, a choice has to be made whether to buy, rent, or lease it. These decisions are given based on the economic standing and strategy of the firm, and the nature and frequency of equipment use.<sup>[2],[10]</sup>

- **Common factors affecting selection of equipment:-**

Every equipment has certain factors those are in common and which are taken into consideration while selecting equipment. They are listed as follows:

1. Scope of work to be carried out since the first concern is getting the job done, the time frame within which the work is required to be carried out, the specification of work and the methodology adopted will be of primary concern

2. Use of available for a work where full utilization of new equipment for its entire working life is not foreseen and its utilization on.
3. Further project is uncertain it may be desirable to utilize existing old equipment even though its operation would be somewhat more expensive. The depreciation cost of new machine is likely to be high and this would rise the owning cost of the machine and consequently unit cost of work. Economic should be worked out.
4. The equipment selected should suit the demands of the job conditions. Climate of region and working conditions should be kept in view while selecting the type of equipment.
5. Uniformity in type it is desirable to have minimum number of types so that there is uniformity in the type of equipment on a project. It is desirable to select common type of engine for different machine such as excavators, dump trucks, tractor and scrapers purchased on the projects.
6. While large size of machines are capable of giving large outputs on full load, the cost of production is usually greater than that of smaller units if worked out on part loads. Large size of equipment requires corresponding large size of matching equipment. And shutting down of one primary unit may result in making several other equipment idle. Transportation and shipment are usually difficult and expensive. However large equipment's are more sturdy and suitable for tough working conditions. It is also desirable to have equipment of same size on the project. If there are standbys the cost of smaller equipment as standby may be less than that of larger size of equipment.

7. Standard equipment are commonly manufactured and are commonly available and are moderately priced. The spare parts of standard equipment are easily available and less expensive. After the work is over, it is generally easier to dispose of standard equipment.
8. Unit cost production the economics is one of the most important considerations in selection of equipment. While working out owing cost all items of expenses, such as freight, packaging and forwarding, insurance, erection and commissioning etc. should be included with the price paid to supplier.
9. Country of origin when imports are unavoidable, it is preferable to import from a soft currency than from a hard currency area, if equipment quality is available.
10. Down time for want of necessary spare parts commonly accounts for long idle periods during working life of equipment, especially of imported equipment. Availability of spare parts at reasonable cost during the entire working life should be assured while selecting a particular type of equipment.
11. Versatility the equipment selected should be if possible, be capable of performing more than one function and should have feature of inter convertibility as far as possible.
12. Selection of manufacturer it is desirable to have equipment of the same manufacturer on a project as far as possible and to have minimum number of different makes of equipment. The quality of local dealers is also important.
13. Available operators and technicians should be able to handle selected equipment.

14.The efficient performance of any piece of equipment and its service life are conditioned by following factors :

- a. Strength.
- b. Rigidity.
- c. Vibration stability.
- d. Resistance to wear.
- e. Heat resistance.
- f. Reliability.
- g.Maintainability.

A balance between reliability, investment cost and operating cost should be found since a policy of selecting the lowest priced equipment can often lead to higher life cycle costs.<sup>[7]</sup>

### **3/Controlling the equipment management during building construction period**

During the construction period, you may have hundreds of pieces of heavy equipment and workers to execute. By making Scheduling to the equipment in the project to coordinate the work between employees. With Scheduling, you can assign equipment and personnel to job sites on a day to day basis. Once scheduled, employees receive an email letting them know when and where they will be working.<sup>[12]</sup>

### **4/The planning process for equipment and methods**

Planning process for equipment and methods is necessary both prior to and during the actual construction of a project.

The planning is required for :-

- Production ;
- Achievement;
- Cost control;

- Coordination of the project and the parties involved in the project;

Formal planning involves the following steps:

- Analysis of a project ( time , money, location,...);
- Identification project activities;
- Estimate of cost , resources to perform each activity;
- Development of plant network;
- Application of realistic limitation to activities. [12]

## CHAPTER THREE

### 3. Methodology

#### 3.1 Introduction

In this research, descriptive analytical method is used to study the improvement of productivity of construction equipment .Through data collection and analysis to statistically test the validity of hypotheses. Researcher visited the site engineering and distributed Questionnaire (70 samples ) for engineering and managerial . Then collected 54 samples were filled . 16 samples were not filled they expressed their unwillingness to respond.

#### 3.2 Design of Questionnaire

In order to reach a good formulation of the questionnaire serve the research objectives and hypotheses, to study construction equipment in practice. Questionnaire models were shown in Tables ( 3-a, 3-b,3-c).

**Table(3-a):The first hypotheses (The heavy equipment have a significant impact in the construction industry)**

| Hypotheses                                                                   | Question                                                                             |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 1.The heavy equipment have a significant impact in the construction industry | The equipment is used in the construction of projects that you performed             |
|                                                                              | The equipment represents a key factor for the implementation of engineering projects |
|                                                                              | The project need preparation of initial studies of equipment                         |
|                                                                              | Heavy equipment helped to reduce the time spent on the site work                     |
|                                                                              | Modern equipment has high costs                                                      |
|                                                                              | Scheduling equipment covers activities available on-site                             |
|                                                                              | Maintenance of equipment are periodically                                            |
|                                                                              | Heavy equipment increase the quality of work                                         |

**Table(3-b):The second hypotheses (Using equipment needs training worker consistent with his work)**

| <b>Hypotheses</b>                                                 | <b>Question</b>                                                                                   |
|-------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| 2-Using equipment needs training worker consistent with his work. | Workers are trained on modern equipments                                                          |
|                                                                   | Workers are trained on modern equipment periodically                                              |
|                                                                   | Training of equipment help workers to increase productivity                                       |
|                                                                   | It requires the use of some of the equipment of certain conditions of workers                     |
|                                                                   | Workers are committed to the implementation of instructions during the operation of the equipment |
|                                                                   | Labor is committed to wearing PPE to avoid injuries occur when they work                          |
|                                                                   | The selection process for the workers according to their qualifications                           |

**Table(3-c): The third hypotheses (Required the use of hand tools in some work)**

| <b>Hypotheses</b>                             | <b>Question</b>                                                      |
|-----------------------------------------------|----------------------------------------------------------------------|
| 3-Required the use of hand tools in some work | Hand tools important in certain project activities                   |
|                                               | The project need preparation of initial studies of hand tools        |
|                                               | Hand tools have high efficiency and increase the quality of work     |
|                                               | Hand tools require constant maintenance                              |
|                                               | Are you believes that hand tools more effective than heavy equipment |
|                                               | Hand tools increase the efficiency and productivity of work          |
|                                               | Hand tools have high cost                                            |
|                                               | Hand tools used in projects that require accuracy                    |

### **3.3 Society and the research sample**

The engineering (civil and architects) and managerial of the project whose work in contractor and consultant company with Random samples in Khartoum State. Researcher were distributed 70 random samples and some companies expressed their unwillingness to respond .

### **3.4 Data Collection Technique**

Per-testing was done before the main data collection to ensure that the questions were clear to all whom target of the search. The questionnaire was filling by (engineering and managerial) and given any explanation needed. The checklist was filling by researcher.

### **3.5 Data Management and Analysis**

First, the data was organized, revised and checked for completeness and accuracy during data entry. The data was analyzed using Statistical Package of Social Sciences (SPSS) version 20. The data was double-checked for any errors and data cleaning was done. An analysis framework was prepared to guide the analysis. Then descriptive analysis was done and where necessary, frequency and percentage as well as chi-square test.

### **3.6 Statistical Package for the Social Sciences Program**

Program (SPSS) is an acronym (Statistical package for social sciences) which means statistical package for social sciences. It is a set of package or comprehensive calculation data, and use this data, and use this program in the scientific research that contain numeric data. The program can read all

types of files, analyzing and extracting results and statistical report, the program allows the user to edit data and adjusted in the form of variables and new data using a formula, as well as save the data in files, and call it or modify the data in files, and call it or modify the data file names, or retrieve data files, and views from by controlling the list of commands and options available in the program, to include all stages of analysis. The software name originally stood for Statistical Package for the Social Sciences (SPSS). It is used by market researchers, health researchers, survey companies, government, education researchers, marketing organization, data miners and others. The original SPSS manual (Nie,Bent and Hull,1970) has been described as one of sociology's most influential books for allowing ordinary researchers to do their own statistical analysis. In addition to statistical analysis, data management ( case selection, file reshaping, creating derived data) and data documentation are features of the base software. It statistics places constraints on internal file structure, data types, data processing and matching files. which together considerably simplify programming. SPSS dataset have a two-dimensional table structure, where the row represent cases ( such as individuals or households)and the columns represent measurements ( such as age, sex, or household income). Only two data types are defined: numeric and text. All data processing occurs sequentially case-by-case through the file (dataset). Files can be matched one-to-one and one-to-many, but not many-to-many. In addition to that cases-by-variables structure and processing, there is separate matrix session where one can process data as matrices using matrix and linear algebra operations.

A test statistic is used in statistic hypothesis testing . A hypothesis test is typically specified in terms of a test statistics, considered as a numerical summary of data-set that reduces the data to one value that can be used to perform the hypothesis test. In general test statistic is selected or defined in such a way as to quantify within observed data, behaviour that would distinguish the null from the alternative hypothesis.

### **3.6.1.Chi-squared test**

Is a statistical hypothesis test. It usually tests the hypothesis that the experimental data does not differ from untreated data .That is a null hypothesis. The distribution of the test statistic is a chi-squared distribution when the null hypothesis is true. The test results are regarded as significant if there is only one chance in 20 that the result could be got by chance. There are three main groups of tests:

- Tests for distribution check that the values follow a given probability distribution.
- Tests for independence check that the values are independent, if this is the case no value can be left out without losing information : these check that all samples taken have the same probability distribution or are from the same set of values.
- **Degrees of freedom**

In statistics the number of values in the values in the final calculation of a statistic that are free to vary. The number of independent ways by which a dynamic system can move without violating any constrain imposed on it is call number of degrees of freedom. In other words the

number of degrees of freedom can be defined as the minimum number of independent coordinates that can specify the position of the system completely. Estimates of statistical parameters can be based upon different amounts of information or data . the number of independent pieces of information that go into the estimate of a parameter are called the degrees of freedom . In general the degrees of freedom of an estimate of a parameter are equal to the number of independent scores that go into the estimate minus the number of parameters used as intermediate steps in the estimation of the parameter itself (e.g. the sample variance has  $N-1$  degree of freedom since it is computed from  $N$  random scores minus the only 1 parameter estimated as intermediate step which is the sample mean . Mathematically degree of freedom is the number of dimensions of the domain of a random vector or essentially the number of free components.

#### **- P-Value**

In statistic the p-value is the probability that using a given statistical summary ( such as the sample mean difference between two compared groups) would be the same as or more extreme than the actual observed results. Statistical hypothesis testing making use in many fields of research such as economics, finance, political, science, psychology, biology criminal justice, criminology and sociology. Their misuse has been a matter of considerable controversy.

## CHAPTER FOUR

### 4.Result and Discussion

#### 4.1. Introduction

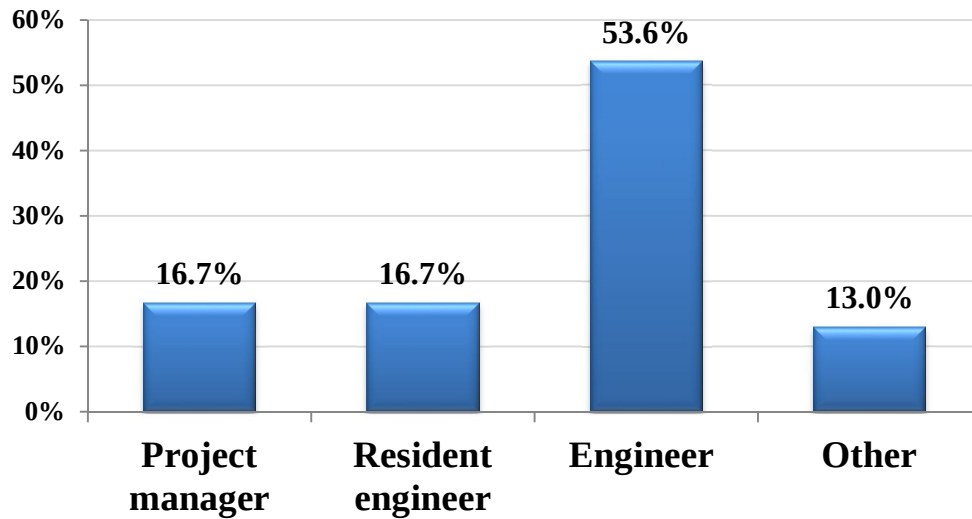
After collecting questionnaire, The data was checked for any errors . The data was analyzed using Statistical Package of Social Sciences (SPSS) version 20. Then result were presented in Tables . The table shows the frequency and percentage for job title were presented in Table (4.1) and Fig.(4.1).

#### 4.2. Section (1) : Personal information

##### 4.2.1. Job Title

**Table (4-1): Frequency and Percentage for Job title.**

| <b>Job title</b>         | <b>Frequency</b> | <b>Percentage</b> |
|--------------------------|------------------|-------------------|
| <b>Project manager</b>   | 9                | 16.7%             |
| <b>Resident engineer</b> | 9                | 16.7%             |
| <b>Engineer</b>          | 29               | 53.6%             |
| <b>Other</b>             | 7                | 13.0%             |
| <b>Total</b>             | <b>54</b>        | <b>100%</b>       |



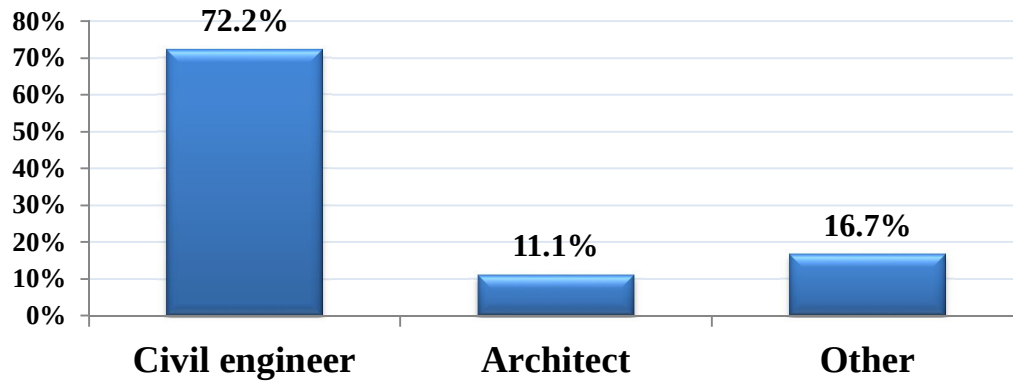
**Fig. (4-1):Percentage for Job title.**

**Fig. (4-1)** shows that the percentage of project manager are 16.7% , 16.7% are resident engineer , 53.6% are engineer , 13% are other. The high Percentage of engineer show that the projects depend on engineer .

#### **4.2.2. Specialization:-**

**Table (4-2): Frequency and Percentage for Specialization.**

| Specialization | Frequency | Percentage  |
|----------------|-----------|-------------|
| Civil engineer | 39        | 72.2%       |
| Architect      | 6         | 11.1%       |
| Other          | 9         | 16.7%       |
| <b>Total</b>   | <b>54</b> | <b>100%</b> |



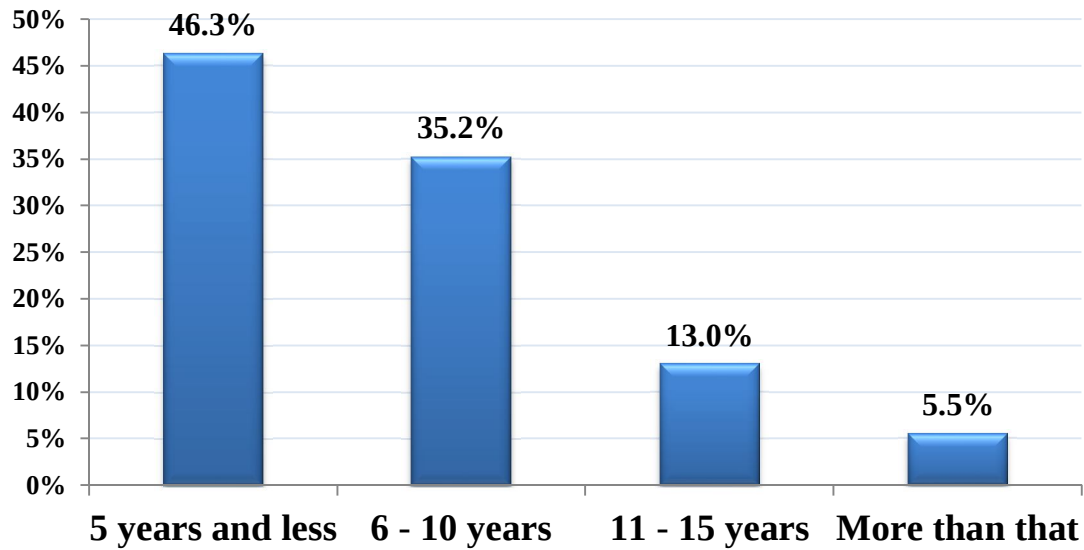
**Fig. (4-2):Percentage for Specialization.**

Fig. (4-2) show that the percentage 72.2% are civil engineer, 11.1% are architect , 16.7% are other . The result show the civil engineer because it is the most important elements in the project.

#### **4.2.3.Experience**

**Table (4-3): Frequency and Percentage for Experience.**

| Experience       | Frequency | Percentage  |
|------------------|-----------|-------------|
| 5 years and less | 25        | 46.3%       |
| 6 - 10 years     | 19        | 35.2%       |
| 11 - 15 years    | 7         | 13.0%       |
| More than that   | 3         | 5.5%        |
| <b>Total</b>     | <b>54</b> | <b>100%</b> |



**Fig.(4-3):Percentage for Experience.**

Fig. (4-3) shows that the percentage of 5 years and less are 46.3% , 32.2% are 6-10 years , 13% are 11-15 years , 5.5% are more than .The result show that the experience ( 5years and less) the highest percentage 46.35% and that indicates the construction project need more experience to avoid risk of project.

**4.3. Section (2) : The heavy equipment have a significant impact in the construction industry.**

**Table(4-4): Frequency(F) and Percentage(P%) for The heavy equipment have a significant impact in the construction industry.**

| Question                                                                             |           | Always      | Sometimes   | Usually     | Often | Never |
|--------------------------------------------------------------------------------------|-----------|-------------|-------------|-------------|-------|-------|
| The equipment is used in the construction of projects that you performed             | <i>F</i>  | <b>41</b>   | 10          | 2           | 1     | 0     |
|                                                                                      | <i>P%</i> | <b>75.9</b> | 18.5        | 3.7         | 1.9   | 0     |
| The equipment represents a key factor for the implementation of engineering projects | <i>F</i>  | <b>43</b>   | 7           | 4           | 0     | 0     |
|                                                                                      | <i>P%</i> | <b>79.6</b> | 13.0        | 7.4         | 0     | 0     |
| The project need preparation of initial studies of equipment                         | <i>F</i>  | <b>18</b>   | <b>18</b>   | 13          | 5     | 0     |
|                                                                                      | <i>P%</i> | <b>33.3</b> | <b>33.3</b> | 24.1        | 9.3   | 0     |
| Heavy equipment helped to reduce the time spent on the site work                     | <i>F</i>  | <b>41</b>   | 9           | 4           | 0     | 0     |
|                                                                                      | <i>P%</i> | <b>75.9</b> | 16.7        | 7.4         | 0     | 0     |
| Modern equipment has high costs                                                      | <i>F</i>  | <b>39</b>   | 11          | 4           | 0     | 0     |
|                                                                                      | <i>P%</i> | <b>72.2</b> | 20.4        | 7.4         | 0     | 0     |
| Scheduling equipment covers activities available on-site                             | <i>F</i>  | 17          | <b>24</b>   | 10          | 2     | 1     |
|                                                                                      | <i>P%</i> | 31.5        | <b>44.4</b> | 18.5        | 3.7   | 1.9   |
| Maintenance of equipment periodically are                                            | <i>F</i>  | 11          | 14          | <b>16</b>   | 11    | 2     |
|                                                                                      | <i>P%</i> | 20.4        | 25.9        | <b>29.6</b> | 20.4  | 3.7   |
| Heavy equipment increase the quality of work                                         | <i>F</i>  | <b>34</b>   | 16          | 4           | 0     | 0     |
|                                                                                      | <i>P%</i> | <b>63.0</b> | 29.6        | 7.4         | 0     | 0     |

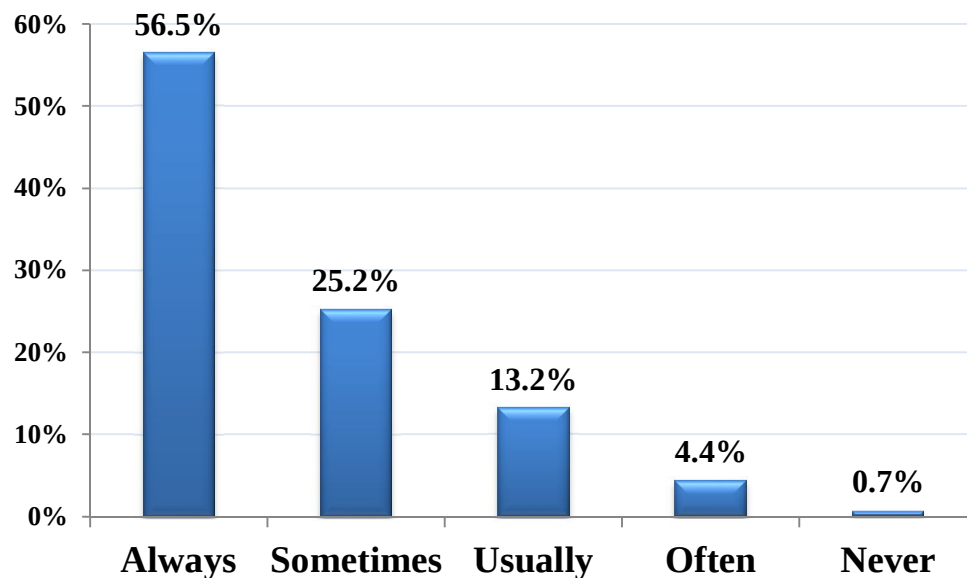
The Table (4-4) shows that 75.9% of equipment are always used in the construction of projects , 79.6% of equipment are always represents a key factor for the implementation of engineering projects , while equal percent 33.3% of equipment are always and sometime that the project need preparation of initial studies of equipment, , 75.9% of heavy equipment are always helped to reduce the time spent on the site work, 72.2% of modern equipment are always has high costs , 44.4% of equipment are sometimes their Scheduling covers activities available on-site, 29.6% of equipment are usually Maintenance periodically and 63% of heavy equipment are always increase the quality of work.

**Table (4-5): Chi square for the heavy equipment has a significant Impact in the construction industry.**

| <b>Question</b>                                                                      | <b>Chi square</b> | <b>Degree of freedom</b> | <b>P value</b> | <b>result</b>                |
|--------------------------------------------------------------------------------------|-------------------|--------------------------|----------------|------------------------------|
| The equipment is used in the construction of projects that you performed             | 78.296            | 3                        | 0.000          | <b>Always</b>                |
| The equipment represents a key factor for the implementation of engineering projects | 52.333            | 2                        | 0.000          | <b>Always</b>                |
| The project need preparation of initial studies of equipment                         | 8.370             | 3                        | 0.000          | <b>Always/<br/>Sometimes</b> |
| Heavy equipment helped to reduce the time spent on the site work                     | 44.778            | 2                        | 0.039          | <b>Always</b>                |
| Modern equipment has high costs                                                      | 38.111            | 2                        | 0.000          | <b>Always</b>                |
| Scheduling equipment covers activities available on-site                             | 35.815            | 4                        | 0.000          | <b>Sometim<br/>es</b>        |
| Maintenance of equipment are periodically                                            | 10.630            | 4                        | 0.031          | <b>Usually</b>               |
| Heavy equipment increase the quality of work                                         | 25.333            | 2                        | 0.000          | <b>Always</b>                |

**Table(4-6): Frequency and Percentage for The heavy equipment have a significant impact in the construction industry Hypotheses statement.**

| Answer       | Frequency  | Percentage    |
|--------------|------------|---------------|
| Always       | 244        | 56.5%         |
| Sometimes    | 109        | 25.2%         |
| Usually      | 57         | 13.2%         |
| Often        | 19         | 4.4%          |
| Never        | 3          | 0.7%          |
| <b>Total</b> | <b>432</b> | <b>100.0%</b> |



**Fig(4-4):Percentage for The equipment have a significant impact in the construction industry Hypotheses statement.**

The result shows that heavy equipment have significant impact in the construction because the engineering use it at all, and they used the heavy equipment in all level of projects ( excavation , Backfilling, Reinforced concrete,

finishing work,...) .The heavy equipment has high cost but it can reduce time, increase quality, high production.

From tables (4-5),(4-6) the hypotheses that say the heavy equipment have a significant impact in the construction industry has be correct.

#### 4.4 Section (3): Using equipment needs training worker consistent with his work .

**Table (4-7): Frequency(F) and Percentage(P%) for Using equipment needs training worker consistent with his work Hypotheses statement.**

| Question                                                                                          |           | Always      | Sometimes   | Usually     | Often       | Never |
|---------------------------------------------------------------------------------------------------|-----------|-------------|-------------|-------------|-------------|-------|
| Workers are trained on modern equipments                                                          | <b>F</b>  | 15          | <b>22</b>   | 6           | 9           | 2     |
|                                                                                                   | <b>P%</b> | 27.8        | <b>40.7</b> | 11.1        | 16.7        | 3.7   |
| Workers are trained on modern equipment periodically                                              | <b>F</b>  | 5           | 16          | 9           | <b>17</b>   | 7     |
|                                                                                                   | <b>P%</b> | 9.3         | 29.6        | 16.7        | <b>31.5</b> | 13.0  |
| Training of equipment help workers to increase productivity                                       | <b>F</b>  | <b>49</b>   | 1           | 4           | 0           | 0     |
|                                                                                                   | <b>P%</b> | <b>90.7</b> | 1.9         | 7.4         | 0           | 0     |
| It require the use of some of the equipment of certain conditions of workers                      | <b>F</b>  | <b>28</b>   | 15          | 5           | 4           | 2     |
|                                                                                                   | <b>P%</b> | <b>51.9</b> | 27.8        | 9.3         | 7.4         | 3.7   |
| Workers are committed to the implementation of instructions during the operation of the equipment | <b>F</b>  | 8           | <b>22</b>   | 11          | 8           | 5     |
|                                                                                                   | <b>P%</b> | 14.8        | <b>40.7</b> | 20.4        | 14.8        | 9.3   |
| Workers are committed to wearing PPE to avoid injuries occur when they work                       | <b>F</b>  | 4           | 13          | 13          | <b>17</b>   | 7     |
|                                                                                                   | <b>P%</b> | 7.4         | 24.1        | 24.1        | <b>31.5</b> | 13.0  |
| The selection process for the workers according to their qualifications                           | <b>F</b>  | 9           | 15          | <b>18</b>   | 10          | 2     |
|                                                                                                   | <b>P%</b> | 16.7        | 27.8        | <b>33.3</b> | 18.5        | 3.7   |

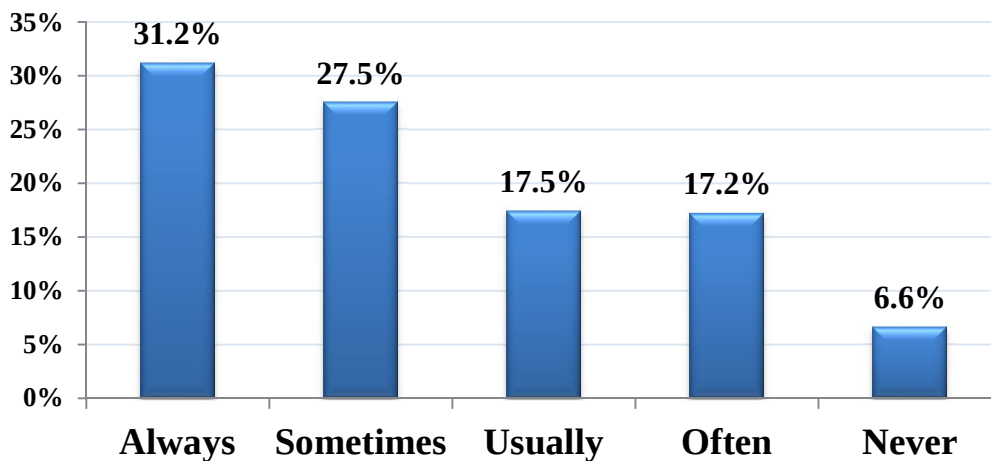
The Table (4-7) shows that 40.7% of workers are sometimes are trained on modern equipments , 31.5% of workers are often trained on modern equipment periodically , 90.7% of training equipments are always help workers to increase productivity , 51.9% of workers are always require the use of some of the equipment of certain conditions , 40.7% of workers are sometimes committed to the implementation of instructions during the operation of the equipment, 31.5% of workers are often committed to wearing PPE to avoid injuries occur when they work and 33.3% of selection workers are usually according to their qualifications.

**Table (4-8): Chi square for Using equipment needs training worker consistent with his work Hypotheses statement.**

| Question                                                                                          | Chi square | Degree of freedom | P value | Result                |
|---------------------------------------------------------------------------------------------------|------------|-------------------|---------|-----------------------|
| Workers are trained on modern equipments                                                          | 22.852     | 4                 | 0.000   | <b>Sometim<br/>es</b> |
| Workers are trained on modern equipment periodically                                              | 10.815     | 4                 | 0.029   | <b>Often</b>          |
| Training of equipment help workers to increase productivity                                       | 80.333     | 2                 | 0.000   | <b>Always</b>         |
| It entails the use of some of the equipment of certain conditions of workers                      | 43.593     | 4                 | 0.000   | <b>Always</b>         |
| Workers are committed to the implementation of instructions during the operation of the equipment | 16.185     | 4                 | 0.003   | <b>Sometim<br/>es</b> |
| Labor is committed to wearing PPE to avoid injuries occur when they work                          | 10.074     | 4                 | 0.039   | <b>Often</b>          |
| The selection process for the workers according to their qualifications                           | 13.963     | 4                 | 0.007   | <b>Usually</b>        |

**Table(4-9): Frequency and Percentage for Using equipment needs training worker consistent with his work Hypotheses statement.**

| Answer       | Frequency  | Percentage    |
|--------------|------------|---------------|
| Always       | 118        | 31.2%         |
| Sometimes    | 104        | 27.5%         |
| Usually      | 66         | 17.5%         |
| Often        | 65         | 17.2%         |
| Never        | 25         | 6.6%          |
| <b>Total</b> | <b>378</b> | <b>100.0%</b> |



**Fig (4-5): Percentage for using equipment needs training worker consistent with his work Hypotheses statement.**

The result shows that using of equipment needs require worker training consistent with his work. The worker isn't trained on modern equipment and that affect in their work. Some worker didn't wearing the PPE when they work. The skills of the worker and their qualifications increase the production.

From tables (4-8),(4-9) the hypotheses that say using equipment needs training worker consistent with his work has be correct.

#### 4.5 Section (4) : Required the use of hand tools in some work

**Table (4-10): Frequency (F) and Percentage (P %) for required the use of hand tools in some work Hypotheses.**

| Question                                                             |           | Always      | Sometimes   | Usually | Often | Never       |
|----------------------------------------------------------------------|-----------|-------------|-------------|---------|-------|-------------|
| Hand tools important in certain project activities                   | <b>F</b>  | <b>38</b>   | 12          | 3       | 0     | 1           |
|                                                                      | <b>P%</b> | <b>70.4</b> | 22.2        | 5.6     | 0     | 1.9         |
| The project need preparation of initial studies of hand tools        | <b>F</b>  | 8           | <b>19</b>   | 8       | 13    | 6           |
|                                                                      | <b>P%</b> | 14.8        | <b>35.2</b> | 14.8    | 24.1  | 11.1        |
| Hand tools have high efficiency and increase the quality of work     | <b>F</b>  | <b>17</b>   | 13          | 9       | 8     | 7           |
|                                                                      | <b>P%</b> | <b>31.5</b> | 24.1        | 16.7    | 14.8  | 13.0        |
| Hand tools require constant maintenance                              | <b>F</b>  | 11          | <b>15</b>   | 12      | 12    | 4           |
|                                                                      | <b>P%</b> | 20.4        | <b>27.8</b> | 22.2    | 22.2  | 7.4         |
| Are you believes that hand tools more effective than heavy equipment | <b>F</b>  | 1           | 11          | 5       | 15    | <b>22</b>   |
|                                                                      | <b>P%</b> | 1.9         | 20.4        | 9.3     | 27.8  | <b>40.7</b> |
| Hand tools increase the efficiency and productivity of work          | <b>F</b>  | 10          | <b>20</b>   | 12      | 6     | 6           |
|                                                                      | <b>P%</b> | 18.5        | <b>37.0</b> | 22.2    | 11.1  | 11.1        |
| Hand tools have high cost                                            | <b>F</b>  | 0           | 4           | 7       | 13    | <b>30</b>   |
|                                                                      | <b>P%</b> | 0           | 7.4         | 13.0    | 24.1  | <b>55.6</b> |
| Hand tools used in projects that require accuracy                    | <b>F</b>  | 10          | <b>13</b>   | 11      | 9     | 11          |
|                                                                      | <b>P%</b> | 18.5        | <b>24.1</b> | 20.4    | 16.7  | 20.4        |

The Table (4-10) shows that 70.4% of Hand tools are always important in certain project activities , 35.2% of projects are sometimes need preparation of initial studies of hand tools , 31.5% of Hand tools are always have high efficiency and increase the quality of work , 27.8% of Hand tools are

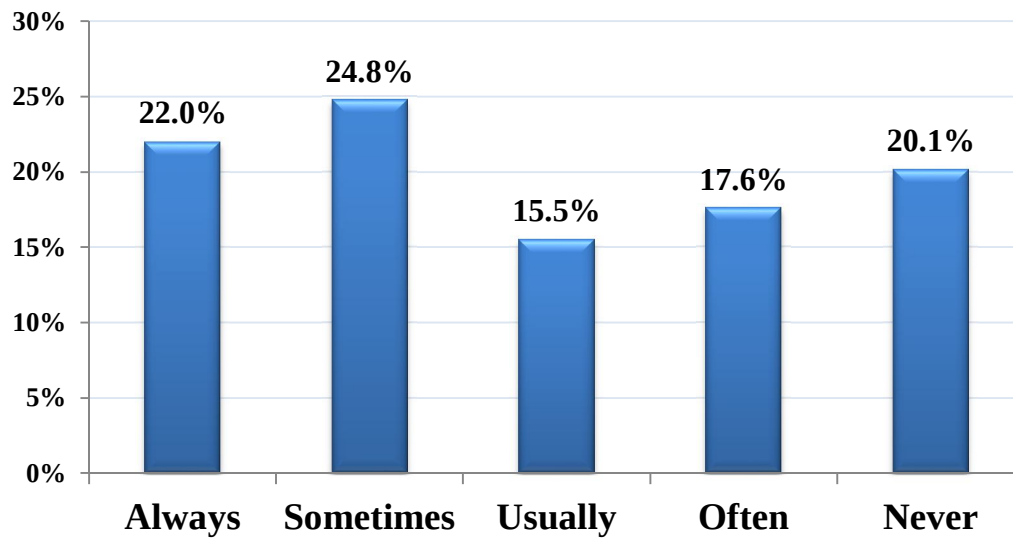
always require constant maintenance, 40.7% of Hand tools are Never effective than heavy equipment , 37.0% of Hand tools are sometimes increase the efficiency and productivity of work,55.6% of Hand tools are Never have high cost and 24.1% of Hand tools are sometimes used in projects that require accuracy.

**Table (4-11): Chi square for required the use of hand tools in some work Hypotheses statement.**

| Question                                                             | Chi square | Degree of freedom | P value | Result            |
|----------------------------------------------------------------------|------------|-------------------|---------|-------------------|
| Hand tools important in certain project activities                   | 64.370     | 3                 | 0.000   | <b>Always</b>     |
| The project need preparation of initial studies of hand tools        | 10.259     | 4                 | 0.036   | <b>Someti mes</b> |
| Hand tools have high efficiency and increase the quality of work     | 6.370      | 4                 | 0.173   | -                 |
| Hand tools require constant maintenance                              | 6.185      | 4                 | 0.186   | -                 |
| Are you believes that hand tools more effective than heavy equipment | 25.259     | 4                 | 0.000   | <b>Never</b>      |
| Hand tools increase the efficiency and productivity of work          | 12.296     | 4                 | 0.015   | <b>Someti mes</b> |
| Hand tools have high cost                                            | 30.000     | 3                 | 0.000   | <b>Never</b>      |
| Hand tools used in projects that require accuracy                    | 0.815      | 4                 | 0.936   | -                 |

**Table (4-12): Frequency and Percentage required the use of hand tools in some work Hypotheses statement.**

| Answer           | Frequency  | Percent       |
|------------------|------------|---------------|
| <b>Always</b>    | 95         | 22.0%         |
| <b>Sometimes</b> | 107        | 24.8%         |
| <b>Usually</b>   | 67         | 15.5%         |
| <b>Often</b>     | 76         | 17.6%         |
| <b>Never</b>     | 87         | 20.1%         |
| <b>Total</b>     | <b>432</b> | <b>100.0%</b> |



**Fig (4-6): Percentage for required the use of hand tools in some work Hypotheses statement.**

Hand tools are important in construction project. It depend on scope of work .If the project is very large and the time of completion is very short we didn't use hand tools. Although hand tools increase the quality in some work. If we build (Mosque, Royal palace, .etc.). They need high technique.

From tables (4-11),(4-12) the hypotheses that say required the use of hand tools in some work has be incorrect.

## **CHAPTER FIVE**

### **Conclusion and Recommendations**

#### **5.1. Conclusion**

##### **Conclusion was summarized as follows**

1. According to the study, equipment always used in the construction project by 75.9%.
2. The equipment always represents a key factor for the implementation by 79.6% of engineering projects.
3. Heavy equipments always help to reduce the time by 75.9% on the site work.
4. Heavy equipment always increase the quality by 63% of work and hand tools always have high efficiency and increase the quality by 31.5% of work
5. Modern equipment always has high costs by 72.2%, and hand tools never have high cost by 55.6%.
6. Workers are trained sometimes on modern equipment by 48.7%.
7. Training of equipment always helps workers to increase productivity by 90.7%.
8. The selection process for the worker usually according to their qualifications by 33.3%.
9. Hand tools are never effective than heavy equipment by 40.7%.
10. Hand tools always important by 70.4% in certain project.

## **5.2.Recommendations**

**Recommendations were summarized as follows:-**

1. Training to reduce the injury of worker and increase productivity, reduce time of work, reduce the cost of equipment (good use of worker).
2. Initial Preparation of equipment project before starting project.
3. Using heavy equipment in big building e.g. (Railway, Brides, Highways, Airport ,etc.).
4. Using hand tools that require accuracy.
5. The study of equipment in Sudan and their production are few, I hope that in the coming years interesting in construction equipment.

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## Appendix

### Sudan University of Science and Technology College of Graduate Students

#### Questionnaire

#### The impact of modern construction equipment management for improving productivity

##### Section (1) personal information :-

##### 1. Job Title: -

Project Manager (    )

Resident engineer (    )

Engineer            (    )

Other            (    )

##### 2-Specialization: -

Civil Engineer    (    )

Architect        (    )

Other            (    )

##### 3 -Experience: -

Less than 5 years (    )

6-10 years (    )

11-15 years (    )

More than that (    )

**Section (2):- The heavy equipment have a significant impact in the construction industry**

| <b>1</b> | <b>The heavy equipment's have a significant impact in the construction industry.</b> | <b>Always</b> | <b>Sometimes</b> | <b>usually</b> | <b>often</b> | <b>never</b> |
|----------|--------------------------------------------------------------------------------------|---------------|------------------|----------------|--------------|--------------|
| 1        | The equipment is used in the construction of projects that you performed             |               |                  |                |              |              |
| 2        | The equipment represents a key factor for the implementation of engineering projects |               |                  |                |              |              |
| 3        | The project need preparation of initial studies of equipment                         |               |                  |                |              |              |
| 4        | Heavy equipment helped to reduce the time spent on the site work                     |               |                  |                |              |              |
| 5        | Modern equipment has high costs                                                      |               |                  |                |              |              |
| 6        | Scheduling equipment covers activities available on-site                             |               |                  |                |              |              |
| 7        | Maintenance of equipment are periodically                                            |               |                  |                |              |              |
| 8        | Heavy equipment increase the quality of work                                         |               |                  |                |              |              |

**Section (3):- Using equipment needs training worker consistent with his work**

| 2 | Using equipment needs training worker consistent with his work                                    | Always | Sometimes | usually | often | never |
|---|---------------------------------------------------------------------------------------------------|--------|-----------|---------|-------|-------|
| 1 | Workers are trained on modern equipment                                                           |        |           |         |       |       |
| 2 | Workers are trained on modern equipment periodically                                              |        |           |         |       |       |
| 3 | Training of equipment help workers to increase productivity                                       |        |           |         |       |       |
| 4 | It entails the use of some of the equipment of certain conditions of workers                      |        |           |         |       |       |
| 5 | Workers are committed to the implementation of instructions during the operation of the equipment |        |           |         |       |       |
| 6 | Labor is committed to wearing PPE to avoid injuries occur when they work                          |        |           |         |       |       |
| 7 | The selection process for the workers according to their qualifications                           |        |           |         |       |       |

**Section (4):- Required the use of a hand tools in some work.**

| <b>3</b> | <b>Required the use of a hand tools in some work.</b>                | <b>Always</b> | <b>Sometimes</b> | <b>usually</b> | <b>often</b> | <b>never</b> |
|----------|----------------------------------------------------------------------|---------------|------------------|----------------|--------------|--------------|
| 1        | Hand tools important in certain project activities                   |               |                  |                |              |              |
| 2        | The project need preparation of initial studies of hand tools        |               |                  |                |              |              |
| 3        | Hand tools have high efficiency and increase the quality of work     |               |                  |                |              |              |
| 4        | Hand tools require constant maintenance                              |               |                  |                |              |              |
| 5        | Are you believes that hand tools more effective than heavy equipment |               |                  |                |              |              |
| 6        | Hand tools increase the efficiency and productivity of work          |               |                  |                |              |              |
| 7        | Hand tools have high cost                                            |               |                  |                |              |              |
| 8        | Hand tools used in projects that require accuracy                    |               |                  |                |              |              |