UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

THE COMPARISONS BETWEEN THE USAGE OF TIMBER AND STEEL FORMWORKS AND THEIR IMPACT ON THE ENVIRONMENT IN THE CONSTRUCTION INDUSTRY WITH PARTICULAR REFERENCE TO SOME SELECTED CONSTRUCTION COMPANIES IN THE ACCRA METROPOLIS

EMMANUEL ANERBOYE ABBEY

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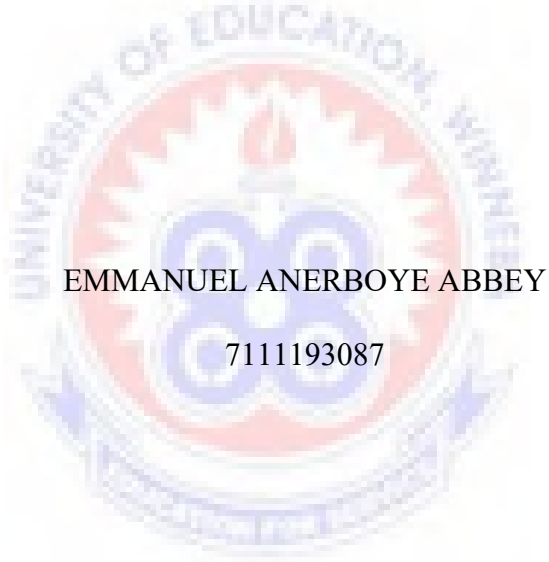

EMMANUEL ANERBOYE ABBEY

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A Dissertation in the Department of CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba in partial fulfillment of the requirements for the award of Master of Technology (Construction) degree.

JUNE, 2014

DECLARATION

STUDENT'S DECLARATION

I, Emmanuel Anerboye Abbey, declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for any other degree elsewhere.

SIGNATURE: ……..……

DATE: ……..……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with guidelines for supervision of Dissertation laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: Mr. S.V. Bour-Frimpong

SIGNATURE: ……

DATE: ……

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DEDICATION

I dedicate this project to my friends who supported me in many diverse ways especially John Fareyson and my children who also were very supportive.

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Glossary / Abbreviations

Glossary

Aesthetics: - Aesthetic is an adjective that is associated with beauty or the appreciation of beauty. It can also be used to describe a state of something designed to give pleasure through its beauty. As a noun, aesthetic refers to a set of principles that underlay and guide the work of a particular artist or any artistic movement. Or is a branch of philosophy dealing with the nature of art, beauty, and taste, with the creation and appreciation of beauty.

Afforestation: - is the establishment of a forest or stand of trees in an area where there was no forest. Or the act or process of establishing a forest especially on land not previously forested.

Agent Orange: - a herbicide containing trace amounts of the toxic contaminants dioxin that was used in the Vietnam War to defoliate areas of forest.

Aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

Archeological: is the study of human activity in the past, primarily through the recovery and analysis of the material culture and environmental data that they have left behind, which includes artifacts, architecture, biofacts and cultural landscapes (the archaeological record).The scientific study of historic or prehistoric peoples and their cultures by analysis of their artifacts,inscriptions, monuments, and other such remains, especially those that hav e been excavated.The study of human history and prehistory through the excavation of sites and the analysis of artifacts and other physical remains.

Biodiversity: - : biological diversity in an environment as indicated by numbers of different species of plants and animals or is the degree of variation of life, this can refer to genetic variation, species variation, or ecosystem variation, within an area, biome, or planet.

Deforestation: - The term deforestation is defined as the elimination of a forest or stand of trees where the land is thereafter transformed to a non-forest use. Deforestation is normally done by logging or burning down the trees.

Ductility: - The property of metal which permits it to be reduced in cross sectional area without fracture. In a tensile test, ductile metals show considerable elongation eventually failing by necking, with consequent rapid increase in local stresses. Ductile is a physical property of a material associated with their ability to be hammered thin or stretched into wire without breaking.

Ecosystem: - An ecosystem is a complex set of relationships among the living resources, habitats, and residents of an area. It includes plants, trees, animals, fish, birds, micro-organisms, water, soil and people.

Environment: - the surroundings or conditions in which a person, animal, or plant lives or operates:

Exacerbate: - To make more violent, bitter, or severe <the proposed shutdown … would exacerbate unemployment problems — Science>: to cause (a disease or its symptoms) to become more severe.

Falsework: - temporary construction work on which a main work is wholly or partly built and supported until the main work is strong enough to support itself.

Formwork: - Formwork in construction is the use of support structures and moulds to create structures out of concrete which is poured into the moulds. Formwork is also used by creating moulds out of steel, wood, aluminium or prefabricated forms into which the concrete is poured.

Global warming: - an increase in the earth's atmospheric and oceanic temperatures widely predicted to occur due to an increase in the greenhouse effect resulting especially from pollution

Greenhouse Gases: - any of various gaseous compounds (as carbon dioxide) that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect.

Gully Erosion:-Gully erosion is a type of soil erosion produced by running water. It is as a result or rapid flow of accumulated runoff water. Gully erosion leads to formation of small valleys or ravines.

Hydrocarbon: - A hydrocarbon is a substance consisting only of carbon and hydrogen atoms. Organic compound (such as benzene, methane, paraffins) made of two element carbon and hydrogen and found in coal, crude oil, natural gas and plant life.

Landscape: - all the visible features of an area of land, often considered in terms of their aesthetic appeal, Landscapes are works of art that feature scenes of nature: mountains, lakes, gardens, rivers, etc. They can be oil paintings, watercolors, gauche, pastels, or prints of any kind.

Logging: - The work or business of felling and trimming trees and transporting the logs to a mill.

No_x: - is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts.

pH: - it is a measure of Hydrogen Ion concentration; a measure of the acidity or alkalinity of a solution. Aqueous solutions at 25℃ with a pH less than seven are acidic, while those with pH greater than seven are basic or alkaline. A pH level of 7.0 at 25℃ is defined as neutral because the concentration H_3O^+ equals the concentration of OH^- in pure water.

Rainforest: - A rainforest is defined as a forest characterized by high rainfall, with definitions based on a minimum normal annual rainfall of 1750-2000 mm (68-78 inches). The intertropical convergence zone usually plays a significant role in creating the climatic conditions necessary for the Earth's tropical rainforests.

Recyclable: - is a process to change materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production

Runoff: -Water from rain or snow that flows over the surface of the ground into streams or the portion of rainfall that runs over agricultural land and then into streams as surface water rather than being absorbed into ground water or evaporating

Scaffolding: - A temporary or movable platform for workers (as bricklayers, painters, or miners) to stand or sit on when working at a height above the floor or ground.

Substructure: - The part of a building that is under it and supports it base framework or foundation that supports a superstructure, and is supported by an infrastructure.

Superstructure: - Construction above the basement or foundation, supported by an infrastructure which in turn is supported by the substructure or is an upward extension of an existing structure above a baseline.

Sustainable: - of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.

Water table: - The water table is the level at which the groundwater is found. If you dig a hole in ground where the soil is permeable and that hole goes below the water table, water will fill the hole.

Abbreviations

REDD: - Reducing Emissions from Deforestation and Forest Degradation.

UNFCCC: - United Nations Framework Convention on Climate Change.

CBD: - Conservation of Biological Diversity (Governmental » Environmental).

ICF: - Images for Conservation Fund (Edinburg, TX).

SNEP: - Sierra Nevada Ecosystem Project.

NFF (G):- National Forest Foundation of Ghana.

UNEP: - United Nations Environment Programme.

NASA: - National Aeronautics and Space Administration.

COP15:- stands for 15th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC - the parent treaty to the Kyoto Protocol).

ABSTRACT

This project is concerned about the comparisons between the usage of timber and steel formworks and their impact on the environment in the construction industry in Ghana. In order to achieve the objectives of the study, some selected construction companies in the Accra Metropolis were used. Although timber formwork has dominated the construction industry worldwide, forests all over the world has been depleted. This has led to greater impacts to economies of poor nations and its people whose livelihood is threatened. In the light of this problem, was whether to continue to use timber as formwork for temporary works or find other alternative materials like steel. Steel is more environmental friendly, recyclable, sustainable and this can reduce logging, save our forests and reduce global warming and greenhouse effects partially or wholly. Although steel formwork application helps reduce construction waste problem, its initial cost is very high and medium and small scale building contractors may not be able to afford its use. Timber for formwork is easily available, cheap easy to work with, on like steel which needs welders and sophisticated welding equipment (welding plant, electricity etc.). The aim of the study is to scrutinize the use of timber and steel from the processing stage to the finish stage as concrete finishing. Some of the objectives are cost involved, availability, uses, speed of erection, striking, strength, handling, waste generation, recyclability, sustainability, environmental friendliness etc. The research design is quantitative and the population of the study concerned is construction companies. Although the stakeholders concerned were many, the researcher has to concentrate was on the final product for formwork. The random method of sampling was used with a sample size of 32 construction companies. Analyses were presented in a descriptive statistical format using the mean score. Questionnaires,

interviews and observations were the research instruments. Percentages were used as a statistical tool for the analysis from the responses of the research instruments. The presentation of data, analysis and discussion of results was carefully done in order to achieve the project objectives. In order to reduce logging and its associated effects on the environment it became necessary that timber used for temporary works as formwork be replaced by steel or a combination of both materials should be used. This would, in the long run help to regenerate our forests, which in turn save our environment from destruction.

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Research has shown that, over the last two decades, massive tracts of virgin tropical forests have come under exploitation. That exploitation with a few honourable exceptions has been reckless; wasteful, even devastating. Nearly all the operations have been enclavistic, that is, to say they have no profound or durable impact on the social and economic life of the countries where they have taken place. Local needs are not met: the employment opportunities are trifling. A significant part of the exports as logs as primary processed timber, is exported 'within the firm', and transfer values are fixed to facilitate the accumulation of profits to the country. The contribution of forestry to improving the lot of the common people has been negligible so far (Forests Monitor Charitable Trust 2006).

Nelleman (2012), states that, forests worldwide bind carbon dioxide and store it – so called Green carbon – and help mitigate climate change. However deforestation accounts for an estimated 17 percentage of global carbon emissions about 1.5 times greater than emissions from all the world's air, road, rail and shipping traffic combined.

Large scale tree cutting can lead to deforestation of an area from forest to terrain of little vegetation. Plants create oxygen and absorb greenhouse gases. The destruction of trees may therefore encourage global warming and changing temperatures can alter the conditions in which organisms can survive in an ecosystem. Cutting trees can result in the loss of habitat for animal species, which can harm ecosystems. According to National Geographic (2013), "70 percentage of the Earths' land animals and plants live in forest and many cannot survive the deforestation that destroys their homes".

Tropical forests like the Amazon rain forest promote a cycle of evaporation and rainfall. Loss of the rain forests could result in warmer and drier climates near the tropics, according to NASA (2010), which could destroy ecosystems that many animal and plants depend on.

According to Martins (2012), the environmental impact of iron ore mining includes erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes. In some cases, additional forest logging is done in the vicinity of mines to increase the available room for the storage of the created debris and soil. Besides creating environmental damage, the contamination resulting from leakage of chemicals also affects the health of the local population. Mining companies in some countries are required to follow environmental and rehabilitation codes, ensuring the area mined is returned to close to its original state. Some mining methods may have significant environmental and public health effects.

Construction of structures has always been a sign of economic growth and social progress. The construction industry in Ghana today has the task of fulfilling this economic benchmark without compromising the serious degradation of our environment to achieve the same purpose of infrastructure development.

A physical structure have component named, piers, column, floor slabs, walls etc. requires the use of formwork. The common type of formwork used in the construction industry is timber and steel.

In view of this situation, the main reason of this research is to compare the uses of both timber and steel formworks for temporary and permanent works and their environmental impact in the construction industry in Ghana.

The selection of a steel formwork system for the construction of substructure and superstructure of buildings and other structures, either bridges or dams would seriously influence the cost, time and quality of project delivery. Other than these issues, environmental objectives and the associated waste production during the course of the construction are also of major concerns.

1.1 Statement of the Problem

In spite of the merits of an increased interest in the use of timber as formwork in Ghana and other parts of the world, it is now alarming globally, that the depletion of the forests by logging is the main cause of extreme weather conditions.

Timber harvesting can have long term effects on the land and the surrounding landscape; the subsequent land use may have even greater impacts. These impacts relate to runoff, gully erosion, stream, water table, wildlife habitat, aesthetics and economics.

Iron ore mining can lead to erosion of exposed hillsides, mine dumps, tailings dams and resultant siltation of drainages, creeks and rivers can significantly impact the surrounding areas, a prime example being the giant Ok Tedi Mine in Papua New Guinea. In areas of wilderness mining may cause destruction and disturbance of ecosystems, habitats, and in areas of farming it may disturb or destroy productive grazing and croplands. In urbanized environments mining may produce noise pollution, dust pollution and visual pollution.

In view of these situations, the main problem of this study was whether to use timber extensively for formwork or choose steel which is environmental friendly, recyclable and

sustainable so as to reduce logging, save our forests and reduce global warming wholly or partially, or combine both materials.

1.2 Purpose of the Study

The purpose of the study was to examine critically merits and demerits derived from the use of both timber and steel formworks and their impact on the environment in the construction industry in Ghana. This study therefore would look at both methods of obtaining the materials and converting them into formwork, cost involved, availability, uses, speed of erection, handling, waste generation, recyclability, sustainability and further more quality of work after usage.

1.3 Aims of the Study

The study aims at investigating the merits and demerits of timber and steel formworks in the building and construction industry in Ghana and their impacts on the environment.

1.4 Objectives of the Study

- To examine the impacts of logging and iron ore mining on the environment.
- To examine the amount of wastes generated during the conversion and processing of logs and iron ore usage for formworks.
- To determine the percentage of wastes generated during the usage of timber and steel units for formworks.
- To determine the number of times both timber and steel formworks can be reused before discarded.
- To examine the initial and the overall cost of both timber and steel when use as formwork in terms of labour, waste generation, sustainability, speed of erection and quality of work.

1.5 Research Questions

After analyzing the above – stated purpose and literature review indicated that the following research questions were appropriate to form the focus of the study:

1. How does logging and iron ore mining affect the environment?
2. How much waste is generated during the conversion and processing of logs and iron ore use for formwork?
3. What percentages of timber and steel units are wasted when use as formwork?
4. How many times do you use timber and steel before they are discarded?
5. What is the initial and the overall cost of timber and steel when use as formwork in terms labour, waste generation, sustainability, speed of erection, quality of work etc.?

1.6 Significance of the Study

- This research is very essential. It would create awareness of the dangers of logging and iron ore mining and give insight into safe methods of mining iron ore. If steel formwork starts to gain roots in the construction industry, the demand for iron ore will be very high.
- Furthermore this research will bring to the attention of management of any construction company and individuals who want to go into industrialization of formwork to be aware of numerous benefits of both formworks.
- It will help formulate policies and reduce conflicts to all stakeholders involved in logging and iron ore mining so that drastic measures are taken to save our environment. It will further scrutinize the types of formwork usage, demerits and

merits of both types of formwork, give suggestions and conclude on the usage of both formworks.

- Construction Industry's Stakeholders.
- Loggers and Sawmill Companies.
- Department of Forestry.
- Mining Companies (Iron Ore).
- Educationists.
- The society at large.

- In addition, introduction of this into our educational curricula would improve practice.
- Just, but not the least, the study would serve as a reference material for academic and other future researchers.

1.7 Scope of the Study

The scope of the study focuses on 55 construction companies: 25 major class A companies, 10 pre-cast concrete manufacturing companies and 20 medium and small scale construction companies. The study was based on the accessibility and type of job undertaken by these companies.

The first stage of the evaluation of the benefits of metal formwork the researcher briefly looked at the raw materials (trees and iron ore) processing to finished products to be used in construction sites as formwork. Details of the effects of processing of the raw materials and their effects on the environment are also considered as well remedial measures.

The second stage is the use of the finished products in construction sites in terms of labour, waste generation, uses, handling, time, finished product, recyclability, sustainability etc. This simply means that there is more emphasis on the final product.

1.8 Limitations of the Study

Due to financial constraints, materials, time and resources, the sample may be very small in relation to the entire population.

The researcher's main problems encountered were during the administration of questions and retrieving them. This was due to the unpreparedness of some of the respondents. Their main complaint was inadequate time for filling of the questionnaires.

1.9 Organization of the Study

The study is made up of five chapters. Chapter one deals with the background of the study, statement of the problem, purpose of the study, aims of the study, objectives of the study, research questions, significance of the study, scope of the study, limitations of the study and organization of the work.

Chapter two focuses on the literature review while the methodology of the study is subject of chapter three. The chapter on the methodology describes the research design, the population of the study, sample and sampling procedures and research instrument. The research instrument comprises of questionnaires, interviews and observations. In addition to the methodology are data collection procedure and data analysis.

In chapter four are results/findings and discussions. Chapter five includes summary of findings, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Wong (1999), states that formwork is one of the most important temporary works for construction of reinforced concrete substructure and superstructure in building and civil engineering projects. The use of conventional timber formwork dominated the construction market in Hong Kong and other parts of the world for many years. Nowadays, low waste construction technologies for substructure and superstructure construction are commonly adopted. The most commonly used low waste construction technology in Hong Kong is large panel steel formwork integrated with pre-cast concrete units.

Compared with the use of conventional timber formwork system, the latter is considered a more sustainable construction method. Stakeholders in the construction industry in the world are consistently exploring the use of innovative construction technologies for various types of construction projects in meeting both economic and environmental requirements.

2.1 History of Formwork

Formwork is the term given to either temporary or permanent moulds into which concrete or similar materials are poured according to Grundy (1981), and in the context of concrete construction, the falsework supports the shuttering moulds.

According to Hurd (1995), formwork originated in the Roman era, when concrete and formwork were used to build superstructures such as the coliseum. Since then, many famous architectural wonders have been erected all over the world, providing many examples of incredible structures which are possible through the use of excellent example

of formwork built during modern times. The dome was created using concrete slab for used in a coffer (a types of concrete mould), creating sunken slabs with which to build the dome.

2.2 Materials Used for Formwork

According to False (2001), the material most commonly used to date is timber. However, due to the depleting forest reserves and increasing cost of timber the use of alternate materials such as plastics, fibre glass, rubbers and steel has become prominent. Faced plywood with a thin surface is required. The strength and robustness of steel makes it ideal for formwork that is to be fabricated into complex forms and shapes.

Aluminum can be used for form faces provided it has some form of coating or protection, to avoid any chemical reaction between the aluminum and wet concrete. Expanded metal is a useful material for construction joint formwork. Glass, reinforced plastics, and other plastics can be used as a form face material. They can produce good finish and can be formed or moulded into complex shapes.

Plastic pipes have been used for column formwork. Formwork for small pre-cast items can be made of plastic. Moulded rubber liner can be used in formwork to produce sculptured surfaces. They can be used for small pre-cast concrete items eg. Garden ornaments, cardboard tubes, usually lined internally with a plastic film, are available for circular columns.

2.3 Types of Formwork

There are two types of formwork, namely permanent and temporary.

Permanent formwork is that which will remain in place after the concreting operation – eg. Precast concrete, bricks and blocks. This may be because of the impracticability of its

removal once the work has been completed, or due to a finish facing material having seen used as the formwork in the first instance.

Temporary formwork is that which is removed completely after the concreting operation – eg. Timber, steel, aluminium, plastic etc. (Seeley 1995, pg 37 – 38).

Temporary and permanent formwork comes in several types.

1. **Traditional Timber Formwork**: - This formwork is built on site out of timber and plywood or moisture – resistance plastic board. It is easy to produce but time consuming for larger structures, and the plywood has relatively short life span (Chudley, 1997).
2. **Engineering Formwork System**: - This formwork is built out of prefabricated modules with a metal frame (usually steel or aluminium) and covered on applications (concrete) side with materials having the wanted surfaces structure (steel, aluminium, timber etc). The two major advantages of this formwork systems, compared to traditional timber formwork are speed of construction (modular system pin, chip or screw together quickly and lower life – circle (Peurifoy and Oberlender, 2005).
3. **Re-usable Plastic Formwork**: - These interlocking and modular systems are used to build widely variable, but relatively simple, concrete structure. The panels are light-weight and very robust. They are especially suited for low-cost, mass housing schemes (Irwin and Sibbald 1983).
4. **Permanent Insulated Formwork**: - This formwork is assembled on site usually out of insulating concrete form (ICF). The formwork stays in place after the concrete has cured, and may provide advantages in terms of speed, strength,

superior thermal and acoustic insulation to run utilities within the EPS layer and integrated furring for cladding finishes (Irwia and Sibbald, 1983).

2.4.0 Timber

Timber, according to Jackson and Dhir (1988), is one of the oldest materials of construction, skill in its use combined with understanding of its nature have together produced many satisfactory solutions to structural and design problems throughout the ages. Such solutions are diverse in range, from the simplicity of primitive huts of indigenous design, through the intricacy and craftsmanship of Gothic screens and roofs to the elegance, scale and strength of many of the glued-laminated structural formworks of today. In addition to its usefulness as a material for structural and applied design because of its relative cheapness, timber has also fulfilled a role in the capacity of temporary structure, allowing materials such as concrete, brick and stone to be erected in structural forms which would otherwise have been vulnerable in the stage before the binding medium gained strength.

It is necessary for those using it to know its nature and limitation. Because timber is a natural material which is not subjected to pre-use factory processing, it is even more necessary that the limitations of use dictated by its natural form be fully understood.

2.4.1 Sources of Timber

Mature trees, of whatever type, are the source of structural timber and it is important that users of timber should have knowledge of the nature and growth pattern of trees in order to understand the behaviour, under variety of circumstances, of those timber elements used in the construction industry. From that understanding there should follow intelligent specification in terms of requirements of performance.

2.4.2 Characteristics of Timber

The principal characteristics of timber with which specifics may be concerned, according to Jackson and Dhir (1988), are;

- Strength.
- Durability.
- Moisture content.
- Finished appearance.

2.4.3 Stress Grading

In order to design a timber structure properly the following properties of the timber should be known;

- Permissible bending stress;
- Permissible shear stress;
- Permissible compressive stress perpendicular to the grain;
- Permissible compressive stress parallel to the grain;
- Modulus of elasticity.

2.4.4 Defects in Timber

According to Desch (1980), defects can occur in timber at various stages, principally during the growing period and during the conversion and seasoning process. Any of these defects can cause trouble in timber in use either by reducing its strength or marring its appearance

2.4.5 Types of Defects

Some types of defects in timber are:

- Grain defect.

- Seasoning defect.
- Conversion defect.
- Chemical defect.

2.4.6 Natural Defects

Seeley (1995), states that, natural defects occur during the growing period and some of these are

- Cracks or fissures.
- Rind gall, burr and curl.
- Knots.
- Fungal decay.
- Insect damage.
- Annual ring width.

2.5.0 Seasoning and Preservation of Timber

According to Seeley (1995), all timber requires treatment with a preservative to enable them to resist infestation and decay. Many timbers have a natural resistance owing not so much to great density and strength but often to the presence of natural oils or resins. Such timbers include cedar, greenheart, jarrah, oak and teak, but their cost may outweigh other considerations such as, for instance, appearance. This makes it necessary to use timbers not so well endowed naturally and to subject them to some form of preservative treatment which will increase their durability.

2.5.1 Reasons for Seasoning

According to Seeley (1995), the following are the reasons for seasoning.

- To prevent shrinkage, splitting, checking and warping.

- To achieve greater stiffness and strength.
- To allow penetration of preservatives.
- To obtain a surface that will accept paint, polish or glue.
- To protect against decay.
- To reduce cost.

2.5.2 Methods of Seasoning

According to Seeley (1995), there are two methods of seasoning timber. They the Air seasoning and Kiln seasoning (Natural and Artificial Seasoning).

2.5.3 Air Seasoning

The timber is stacked on foundations to keep it off the ground. Strips of wood (about 38 x 19 mm) are placed between the layers of boards to allow air to circulate. Ends of boards may be painted to retard drying and prevent splitting.

A waterproof shed with covering is placed over the stacked timber to protect the timber from the sun and the weather. Air seasoning is slow, taking up to a year for a piece 25 mm thick and considerably longer for thicker pieces. But the timber produced is well suited to outdoor work.

2.5.4 Advantages of Air Seasoning

- No expensive equipment needed.
- Small labour cost once stack is made.
- Environmental friendly-uses little energy.
- Less case hardening.
- Defects like cupping, bowing, twisting etc. are minimized.

2.5.5 Disadvantages of air seasoning

- It takes much longer than kiln seasoning.
- Large area of space required for a lot of wood.
- It is notable to produce timber not dry enough for use in the dry, centrally heated air of modern buildings.
- It is more liable to insect and fungal attack

2.5.6 Kiln Seasoning

According to Smulski (1997), kiln seasoning is done in a large oven-like structure in which air circulation, humidity and temperatures are controlled. The timber is stacked on the trucks in the same way as for air drying. The trucks are on rails so that they can be moved into the kiln. Care must be taken to see that the drying process while removing the free water is not too rapid, as at this stage the timber is susceptible to degrade (damage) by checking and collapse. Many types of softwood can be kiln dried easily and fairly cheaply from the green condition. But many of hardwoods are so slow in drying that their kiln drying is uneconomical. It is, however, satisfactory and economic to season them by the combined process of air and kiln drying mentioned below.

According to Smulski (1997), the following are the advantages and disadvantages of kiln seasoning of a timber.

2.5.7 Advantages of Kiln Seasoning

- It dries quickly.
- It can be controlled.
- Achieved lower moisture content.
- Defects associated with drying can be controlled.

2.5.8 Disadvantages of Kiln Seasoning

- It is an expensive method.
- Requires supervision by a skilled operator.
- Uses a lot of energy.
- The strength of the timber is reduced considerably.

2.5.9 Types of Preservatives

Preservatives are chemicals used in the treatment of timber to prevent fungal (decay) and insect attack. According to Seeley (1995), types are many and varied within the definition that any preservative must possess qualities which are poisonous to agents of decay. Nevertheless, for practical purposes only a few are in use because they meet all or most of the following requirements; toxicity to wood-destroying insects or fungi; permanency, economy and availability; penetrability; nonpoisonous nature to humans, plants and animals; noncorrosive; non-promoting of flammability. Some types of preservatives for timber are;

- Tar-oil preservatives
- Water-soluble preservatives
- Organic solvent preservatives

2.5.10 Preparation for Preservative Treatment

According to Wayne and Wilcos (1991), this consist basically of seasoning to a moisture content which varies with the species of tree and moreover, with the method of impregnation. Ideally all cutting and machining should have been completed and all timber should be clean and surface-dry. It is sometimes necessary with certain timbers to incise regularly spaced slits in the timber as a means of improving the penetration of the

preservative. Where it is necessary to cut timber after it has been treated with preservative, the exposed surfaces should be re-treated. This can be most easily accomplished on site by standing the cut timber in a container filled with a suitable preservative.

2.5.11 Methods of Preservation

This varies from a surface treatment of notional protective value to full pressure impregnation. The following methods are arranged in ascending order of efficiency and effectiveness;

- Brush application.
- Deluging, dipping or steeping.
- Open tank application.
- Pressure application.

2.6 Impacts of Logging and Subsequent Land Use

According to Rojas-Briales and Maya (2011), most of the forest-dependent local peoples in tropical forests have lived on their lands for hundreds, if not thousands, of years. The land and the forests are their most important economic resource, providing them with food, building materials, medicinal plants and other products to meet their subsistence needs. Their relationship with the land has formed the cornerstone of many of their societies and cultures and has a deep significance in their spiritual lives, often representing the past and the future as well as the present. Because forests are so central to their lives, most forest peoples have devised ways of forest management which ensure that their needs are met and that the forest ecosystem is protected.

The negative social impacts caused by industrial logging are all too often overlooked in assessments of the damage caused by logging, particularly the high numbers of people affected, the wide-reaching nature of the problems created in people's lives and the potential costs in economic terms of replacing the lost benefits provided by forests.

2.7 Impacts of Watersheds, Aquatic Environments and Road Building

According to Kibria, Rahman, Imtiaj and Sunderland (2011), the end result of logged landscapes is a highly altered forest system which creates significant problems related to erosion, sedimentation and altered stream flow patterns. Logging removes large trees that normally fall into streams and provide shelter and thermal cover, raises water temperatures and pH, and degrades the chemical and ecological conditions and food webs that fish need to survive. According to Sierra Nevada Ecosystem Projects (SNEP) report (1996), logging and the roads created to facilitate logging also significantly degrade stream ecosystems by introducing high volumes of sediment into streams, changing natural stream flow patterns, and altering stream channel morphology. Areas that have been logged are far more likely to suffer from major landslides and erosion events which deposit abnormally high levels of sediment into area streams. Roads, ditches, and newly created gullies form new, large networks of flow paths across the landscape. These logged areas therefore, sustain much higher discharge volumes after a storm event than they ever did when the forest was intact.

2.8 Introduction of Diseases

According to National Geography (2013), logging increases the likelihood of the introduction and spread of lethal tree diseases through a variety of methods. Stumps left behind after logging operations have a much higher incidence of infections than do living trees. Once a disease enters an area through a stump it is likely to spread to surrounding

trees that otherwise would not have been exposed to such threat. The debris left behind after logging operations, often referred to as slash, also invite disease and insect pests.

2.9 Wildfire Risk

According to the Sierra Nevada Ecosystem Project's (SNEP) report (1996), timber harvest, through its effects on forest structure, local microclimate, and fuels accumulation, has increased fire severity more than any other recent human activity. If not accompanied by adequate reduction of fuels, logging (including salvage of dead and dying trees) increases fire hazard by increasing surface dead fuels and changing the local microclimate. Fire intensity and expected fire spread rates thus increase locally and in areas adjacent to harvest. This conclusion supports the consensus view of fire ecologists that logging operations greatly increase the fire risk on a forest.

2.10 Global Warming

According to NASA (2010), logging old forests also contributes to global warming through removing significant sources of sequestered carbon. After logging, the local microclimate is also altered, resulting in hotter and drier conditions which contribute to increased fire hazard. These and other types of feedback loops can hasten rapid climate change. Research shows that old-growth forests in the Northern Hemisphere sequester large amounts of carbon for many centuries, whereas the disturbance associated with logging and planting conifer monocultures creates net carbon emissions for decades. When added together, the cumulative impacts of logging in the Sierra Nevada as currently practiced is not sustainable and if allowed to continue, will endanger not only the fish and wildlife, plants and ecology of the region, but will harm human health and welfare as well. Timber harvesting can have long-term effects on your farm and the surrounding landscape; the subsequent land use

may have even greater impacts. These impacts relate to runoff, gully erosion, in-field erosion, streams, water tables, wildlife habitat, aesthetics and economics. The nature and extent of the impacts will depend on the logging practices, subsequent land use and landscape characteristics.

2.11 In-Field Water Erosion

According to Lee, Von-Maltitz and Mathai (2012), in-field water erosion refers to soil removal by raindrops hitting the ground and runoff flowing as sheet flow or in small rills. Characteristics that increase the risk of in-field erosion include:

- steep slopes or long, uninterrupted slopes;
- sandy or silty soils;
- soils without a protective vegetative cover;
- reduced infiltration resulting from low permeability at or near the soil surface (due to soil crusting, frozen soil, fine textured soil, shallow soil or other characteristics); and
- Soils low in organic matter.

2.12 Wind Erosion

Nelleman (2012), states that depending on the subsequent land use, logging can also increase the risk of soil erosion by wind. Conditions promoting wind erosion include:

- Sparse or absent vegetative cover.
- Dry, loose and finely aggregated soil.
- Smooth soil surface.
- Large fields.
- High velocity winds.

Vegetative cover, including crop residue, is particularly important in reducing wind erosion. It anchors the soil, increases surface roughness, reduces wind speed, conserves soil moisture and adds organic matter which helps bind the soil particles into aggregates. Clearing and cultivating land removes the vegetative cover for part or all of the year. Large, open fields are especially erosion prone because long, unobstructed distances allow the wind's velocity to increase.

2.13 Streams

According to National Geography (2010), tree roots help stabilizes stream banks, and tree shade helps reduce algae growth in streams in some cases. Streamside vegetation also traps sediments before they reach the stream and absorbs nitrates from groundwater. Clearing trees removes these benefits.

Stream banks can also be damaged by equipment or livestock trampling, resulting in reduced water quality and increased sedimentation. In extreme cases, stream banks may be destroyed, and the diverted stream flow can cause flooding and sedimentation in new locations.

2.14 Water Tables

Nelleman (2012), states that trees act as living pumps that draw moisture out of the soil and release it into the atmosphere. At the same time, tree shade and shelter may prevent excessive evaporation from dry sites. Depending on topography, soil and availability of water, clearing trees can have one or more of the following effects on water tables and associated site conditions:

- Waterlogged soils those are difficult to reforest or crop.
- Reduced soil moisture and drying of existing wetlands.

- Fluctuating water tables causing increased soil salinity or changes in soil pH.
- Problems with water quantity or quality in existing dugouts, springs or wells.

2.15 Military Context

Austin and Bruch (2000), cites war can also be a cause of deforestation, either deliberately such as through the use of Agent Orange during the Vietnam War where, together with bombs and bulldozers, it contributed to the destruction of 44% of the forest cover, or inadvertently such as in the 1945 Battle of Okinawa where bombardment and other combat operations reduced the lush tropical landscape into "a vast field of mud, lead, decay and maggots".

2.16 The Challenge

How do we ensure that forest exploitation does not lead to environmental degradation? How can the rights of indigenous peoples and forest-dependent communities be guaranteed? How do we achieve equitable development and conservation of forest lands, with the fair distribution of benefits between the state, local populations and private companies?

Forest Monitor Charitable Trust (2006), suggests that the solutions to these questions will entail radical changes in policy and new approaches to forest management. Forests Monitor is working to bring about these changes through:

1. Providing accurate information to civil society and local populations on the activities of logging companies. This enables local communities to make informed decisions and lobby more effectively for change.
2. Building technical capacity of both civil society and government in forest law enforcement and governance through the provision of training. Forest Monitor's

capacity building programmes are designed to address specific weaknesses identified through consultation with partners. In this area of work, Forests Monitor works closely with Resource Monitoring Extraction (REM), a non-profit NGO which specializes in independent monitoring of extractive industries.

3. Supporting the development of community forestry as a means to secure the rights of forest-dependent peoples and to enable them to pursue their own development goals.
4. Lobbying for policy change and/or enforcement of existing policies that will support forest management that really contributes to poverty alleviation.

2.17 Rationale

The work of Forests Monitor is framed by a range of international policy processes. These include those linked directly to forests as well as those related to biodiversity conservation, development, climate change and trade. Some of the key policies that inform our work are:

- The United Nations Framework Convention on Climate Change (UNFCCC): Within the framework of this Convention, negotiations are underway to explore options for including forests within an international agreement on climate change. This includes the development of financial mechanisms to reduce greenhouse gas emissions from deforestation and forest degradation (known by the acronym REDD).

  For any REDD mechanism to be effective, the rights and needs of forest-dependent and indigenous communities must be addressed. Also critical will be effective forest governance. This will entail, among many other aspects, reform and implementation of the law, as well as the establishment of systems to monitor

changes in forest cover and quality and to ensure the equitable distribution of any benefits.

Forests Monitor has been following these negotiations and is exploring ways in which its expertise can help ensure that forest carbon initiatives, such as REDD, would operate in such a way as to ensure equity and accountability.

The Forests Principles (the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all types of Forests): Forests Monitor is guided in particular by Forests Principle 2(c): "The provision of timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision making and should be ensured."

- The Millenium Development Goals: Forests Monitor's work seeks to contribute to the achievement of the 7th Millennium Development Goal, to ensure environmental sustainability. This includes the targets to reduce biodiversity loss, slow deforestation and contain rising greenhouse gas emissions.
- The Convention on Biological Diversity: The CBD includes a programme of work dedicated to forest biodiversity. This programme has a number of goals, of which those of particular interest to Forests Monitor include: promoting the sustainable use of forest resources, including through the support of indigenous and local communities to manage forests; and promoting the fair and equitable sharing of benefits resulting from the use of these resources and of associated traditional knowledge.

2.18 Illegal Farming Destroying Forests

Asamoah-Dwomoh (2013), warns of imminent loss of Ghana's entire forest cover if efforts are not put in place to stop illegal farming in forest reserves, that Ghana has lost the vegetative cover of most of its forest reserves and by the turn of the 20th Century, it has shrunk from 8.2 million to 1.6 million hectares. Currently, some of the remaining reserves were losing as much as 90 per cent of the cover.

He called on Ghanaians to take measures to stop the wanton and unacceptable forest practices, which were on the increase in the country.

According to Asamoah-Dwomoh (2013), although the government has signed initiatives like Voluntary Partnership Agreement, which seeks to ensure sustainable management of the forests, perpetrators continued with forest degradation activities with impunity and this was partly because of the inability of authorities to deal drastically with offenders due to alleged interference by some influential community leaders and political "heavy weights". This has gingered others, especially the youth, to join this devastating activity whilst the technocrats and traditional authorities look on helplessly.

2.19 Reforestation

According to Botkins (2013), and Sedjo (2010), in many parts of the world, especially in East Asian countries, reforestation and afforestation are increasing the area of forested lands. The amount of woodland has increased in 22 of the world's 50 most forested nations. Asia as a whole gained 1 million hectares of forest between 2000 and 2005. Tropical forest in El Salvador expanded more than 20% between 1992 and 2001. Based on these trends, one study projects that global forest will increase by 10%—an area the size of India—by 2050.

2.20 Forest plantations

Botkins (2013), and Sedjo (2010), suggests that to meet the world's demand for wood, high-yielding forest plantations are suitable. It has been calculated that plantations yielding 10 cubic meters per hectare annually could supply all the timber required for international trade on 5% of the world's existing forestland. By contrast, natural forests produce about 1–2 cubic meters per hectare; therefore, 5–10 times more forestland would be required to meet demand. Oliver (1995), a forester, suggests a forest mosaic with high-yield forest lands interspersed with conservation land.

In the country of Senegal, on the western coast of Africa, a movement headed by youths has helped to plant over 6 million mangrove trees. The trees will protect local villages from storm damages and will provide a habitat for local wildlife. The project started in 2008 and already the Senegalese government has been asked to establish rules and regulations that would protect the new mangrove forests.

2.21.0 Iron Ore (Steel)

Blake (1994), states that iron ore is a mineral, forming naturally over geological periods in the ground and within rocks. It is one of the most common elements on earth, comprising about 5 per cent of the earth's crust. Rocks containing iron ore often date to more than 2,500 million years old. It is the key ingredient in the production of steel.

2.21.1 How Iron Ore is Mined

Explosives are used to blast through surface rock to access iron ore deposits below the ground. Haul trucks transport the ore to crushing plants, where the ore is crushed into smaller pieces of varying sizes. Crushed ore is then classified into different sizes based on customer specifications. The ore is next transported via rail to ports for shipping to

overseas customers or smelters. Iron ore usually ends up in blast furnaces and steel mills, where it is turned into iron and steel through smelting and refining.

2.21.2 How Iron Ore is processed

According to Burns (1994), iron ore is smelted in blast furnaces to produce pig iron. In a blast furnace, coke and ore are fed through the top of the furnace while heated air is blasted into the bottom of the furnace at temperatures of around 2000°C. The chemical reactions that take place as the ore and coke move down creates molten metal and slag which settle to the bottom of the furnace, where the molten slag floats on top of the more dense molten iron. Iron and slag are tapped off separately from the blast furnace. Once cooled, the iron is called pig iron. Pig iron is not pure iron as it has 4 to 5 per cent carbon in its make-up. Pig iron is used to produce steel or commercially pure iron (wrought iron) through further smelting and refining in furnaces and converters.

2.21.3 Effects of Iron Ore Mining on the Environment

Shastri (2010), claims that iron ore mining in India created a lot of environmental problems. The following summaries are the impacts of iron ore mining.

i. Changes in drainage pattern.

ii. Changes in top soil composition by runoff from the overburden dumps.

iii. Damage to archaeological / religious monuments.

iv. Increase in temperature in the area – due to industrial activity, and decrease vegetation.

v. High SPM level due to vehicle movement and other operation.

vi. Drilling and blasting contribute to explosive fumes.

vii. Increase in No_x, hydrocarbons, CO and land level due to diesel equipment, generators, vehicle movement etc.

viii. Increase in ambient noise.

ix. Removal of surface water bodies.

x. Depletion of ground water – Pumping of high pressure aquifers, below the mineral deposits.

The rainforest is under assault from a variety of sources and, compared to soya bean planting and cattle grazing, iron ore mining causes relatively minor damage when all the precautionary measures are taken during and after the mining operation is ended according to Martins (2012).

2.21.4 Iron Ore And Its Uses

According to Reynolds, and Kent (1972), steel which is to be used in general building construction is subject to a number of standardized requirements. The standards of quality required are laid down in one of the standards issued by the British Standards Institution. These standards are known as BS (British Standards), and that relating to structural steel for general building work is BS 4360.

A substance which plays an important part in the type of steel in building construction is the element carbon. The percentage of carbon in steel directly influences its essential structural properties. An increase in carbon content results in an increase in strength, but this is accompanied by a marked decrease in ductility. Ductility or absence of brittleness is one of the important requisites of a structural steel. It promotes equalization of load between the steel fibres of a member of such importance is this property of ductility that, in

the commercial testing of structural steel, an upper limit of strength is prescribed for the steel in addition to a definite minimum value for the percentage elongation.

Steel is a metal (an alloy) which has been made from various elements such as silicon, nickel, copper and manganese which increases in strength, hardness and corrosion resistance. The two main elements that comprise steel are iron and carbon. Iron is by far the main ingredient in terms of percentages, usually making up roughly 98% of all the components found in steel. Carbon typically will comprise less than 0.5% of steel but is very important because it affects the steel's strength and hardness. In mild carbon steel, where the content is increased will produce stronger and harder steel. The presence of carbon and iron makes it non-metallic compound under certain temperatures, which is very hard and brittle.

According to Trefor and Lewis (1972), if the metal chromium is introduced into the composition, the resulting steel is able to exhibit among other useful properties, a pronounced resistance to rusting and is given the name stainless steel. The element manganese, on the other hand, gives good wearing properties to steel, making it suitable for use in the manufacturing of rails. There are therefore various types of steels, known respectively as chromium steel, manganese steels and so on according to the alloy elements which give the steels their characteristic properties.

Steel, referred to us the engineer’s material is manufactured and can therefore be designed and formulated to specific strength. It is uniform and isotropic. Steel forms are mostly used in construction project or in situations where large numbers of reuses of the shuttering are possible. Steel formworks are extensively used for repetitive casting of pre-cast concrete products.

2.22.0 Description of Materials Used for Formwork

According to Peurifoy and Oberlender (2005), materials used for forms for concrete structures are lumbers, plywood, hardboard, fiberglass, plastics, fiber forms, corrugated boxes, steel, aluminium, magnesium and plaster of paris. Among the properties that form materials should possess are as follows:

1. Adequate strength.
2. Adequate rigidity.
3. Surface smoothness where required.
4. Economy, considering initial cost and number of reuses.

Formwork refers only in timber formwork as any type of wooden construction, including structural support, designed to enable concrete, cement or other materials to be poured into it in a fluid state to assume a particular shape upon setting but it is in general the mould to shape the concrete structure. Good concrete cannot be made from a poor mould; as a result formwork is very important in producing good concrete. Besides that, it has to be designed to take the concrete load and the working load generated from workers and plant. An excessive deflection or leakage and not well-fitted mould which loose grout and weaken the concrete can destroy the appearance of the concrete product. Moreover, a leaky joint can cause honeycombing and joint marks on the face of concrete. The concise description of formwork seeks to provide definition and works of various individuals which will go to enlighten the contractor further on the importance of formwork in the finished project.

Most structural concrete are made by placing plastic concrete into spaces enclosed by previously contracted forms. The plastic concrete hardens into the shape outlined by the forms, after which the forms are usually removed.

It can be said without a thought that most often designers of concrete structures devote considerable time selecting the minimum amount of concrete and steel for a structure without devoting adequate attention to the impact of the formwork that must be constructed to form the concrete structure.

For most structures, more time and cost are required to erect and remove formwork than the time and cost to place the concrete or reinforcing steel. For some structures, the cost of formwork even exceeds the cost of the concrete and steel combined.

According to Peurifoy and Gerald (1996), the level of effort required to produce a good formwork is important as the level of effort required to produce the right combination of steel and concrete for the structure system of the concrete structure. They also state that the purpose of formwork is to safely support the reinforced concrete until it has reached adequate strength to support itself. Hence they said formwork is a temporary support for the permanent steel and concrete.

Also Seeley (1995), states that the formwork is used to retain concrete in specific location until the concrete has developed sufficient strength to stay in position without support. Therefore a very good or the overall quality of a completed project is dependent highly on the formwork used.

It is therefore the responsibility of the designer to produce an efficient and good formwork system that is safe, economical, strong and easily constructible at the jobsite.

2.22.1 Basic Principles of Formwork Systems

The design and fabrication of every formwork systems must be based primarily on a number of principles. This according to Blake and Burns (1994), they are as follows:

1. The side of formwork must be designed to offer all the necessary resistance to the imposed pressure as a single member. Alternatively, it can be design with a thinner material, which needs to be strutted adequately.
2. Also the sides should be designed to limit widths and shape of the concrete as well as to resist the hydrostatic pressure of the net concrete which will eventually decrease to zero within a matter of hours depending on setting and curing rate.
3. Formwork soffits must be designed to offer all the necessary resistance to the imposed loads as a single member or alternatively can be designed with a thinner material with sufficient propping.
4. Base and soffit of formwork should be designed to limit the depth and strap of concrete and must resist the initial dead load of the wet concrete until it has gained sufficient strength to support its own dead weight which is usually several days after casting based on the rate of setting and hardening.

2.22.2 Factors Influencing the Choice of Formwork

The choice of formwork system has to be governed by several factors. These according to Hurst (1983), include:

- Availability of formwork element;
- Whether the formwork is to be hired or purchased;
- The design of the formwork; and
- Available plant.

2.22.3 Check List

This section contains checklists of activities which need to be carried out before concrete is placed in formwork. According to Johnson and Wheeler (2005), some of these activities are;

Formwork

- Correct position.
- Line and level.
- Accuracy within permitted tolerances.
- Shape of members.
- Verticality (plumb).
- Correct angles for batters etc.
- Finishing heights (mark off).

Joint

- Formwork joints flush and tight.
- No nails protruding into the concrete.
- Formwork joints sealed as required.
- Construction joints strutted and supported.

Water stops

- Correctly positioned.
- Fixed and suitably supported.

Ties and Fixings

- Correct number.
- Correct lengths.

- Tight enough and not too tight.
- Fitted with the proper washers.

Finish

- All forms perfectly cleaned out.
- Release agents correctly applied.

2.22.4 Steel Formwork Fixing

According Irwin and Sibbald (1983), steel reinforcement is produced in standard length which is governed by the limitation of transportability and weight considerations in bending and fixing. Consequently, there are generally three types of splicing:

Lap splicing which depends on full bond development of the two lapping bars at the lap.

1. Mechanical connection which can be achieved by mechanical sleeves threaded on the ends of the bar to be interconnected. It is used under space limitations or heavy reinforced structural elements.

2. Welding by fusion; welding is not recommended when splicing for high tensile reinforcement. Because of the large amount of heat required in the welding process, the properties of the bar will be affected in the area of the weld. If bars are to be welded, special weldable reinforcement should be specified by the engineer.

Reinforcement should also be adequately embedded in order to prevent slippage and bond pull-out failure. To ensure adequate end anchorage, the bond stress obtained by dividing the force in a bar by the contact area between the concrete and reinforcement must not exceed the limiting ultimate anchorage-bond stress.

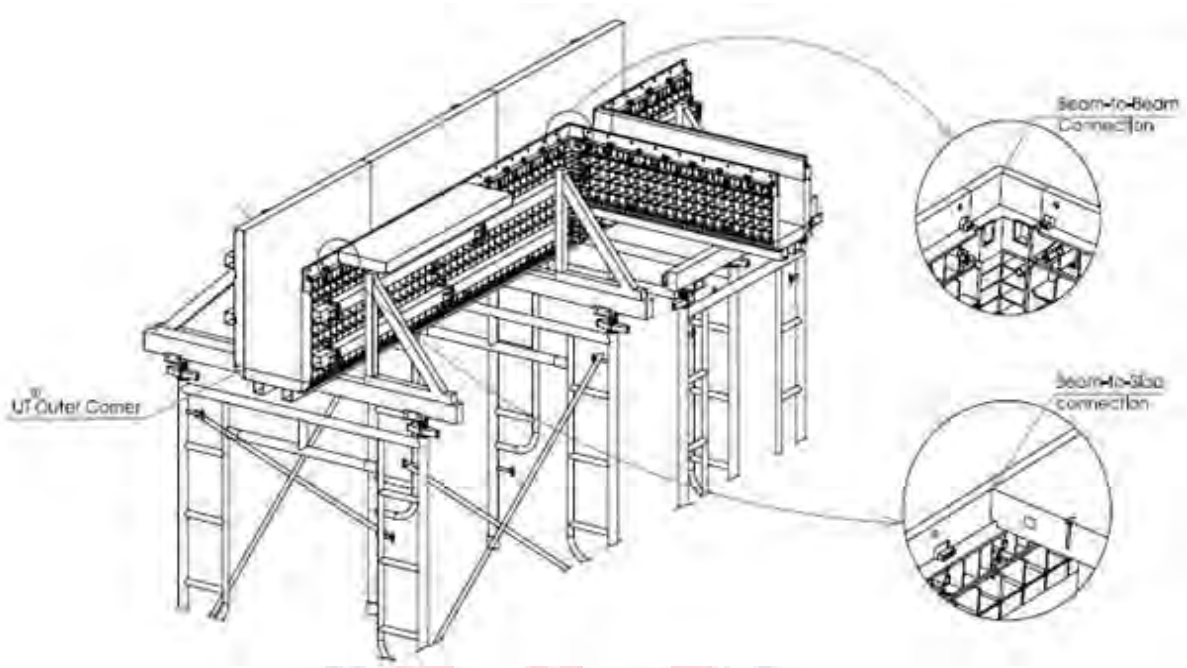

FIG. 2.1. Details of Beam and Slab Steel Formwork

Source: Hunnebeck, Streif Baulogistik – Steel Formwork

2.22.5 Advantages and Disadvantage of Steel Formwork

Advantages

According to Baulogistik (2010), the following are the advantages and disadvantages of steel formwork.

i. Strong, durable and have longer life.

ii. Reuses can be assumed to vary from 100 to 120 whilst timber varies from 10 to 12.

iii. Steel can be installed and dismantled with greater ease and speed resulting in saving in labour cost.

iv. Excellent quality of exposed concrete surface obtained. Thus saving in the cost of finishing the concrete surface.

v. No danger of formwork absorbing water from the concrete and hence minimizing honeycombing.

vi. Low waste generation.

vii. Environmental friendly (can be recycled without causing environmental problems).

viii. It is sustainable.

ix. It speeds up the work.

x. Versatility.

Disadvantages

i. Very high initial cost.

ii. Limited size or shape.

iii. Excessive loss of heat.

iv. A very smooth surface will be produced which would give problem for finishing process.

v. Limited fixing.

2.22.6 Functional Requirements

According to Seeley (1977), the general requirements of formwork are as follows;

i. It should be sufficiently rigid to prevent undue movement during the placing of the concrete to produce a good concrete appearance.

ii. Erection and stripping shall be easily performed with units of manageable size.

iii. It must have sufficiently right points to prevent loss of fine materials from concrete.

iv. It must permit removal of side forms prior to striking of soffit shuttering.

Also Chudley (1998), states that for a formwork to effectively serve its purpose it must satisfy the following requirements;

i. It must not be able to deflect under loads which would include the loading of wet concrete self-weight and any superimposed loads such as operatives and barrow runs over the formwork.

ii. It must be strong enough to support the load of wet concrete, which is generally considered to be approximately 2400kg/m^3

iii. It must be accurately set out because concrete being a fluid when placed will take up the shape of the formwork and must therefore be of the correct shape, size and in the right position.

iv. It must have grout tight joints. Grout leakage can cause honey combing of the surface or produce fins which have to be removed. The making of good defective concrete surface is both time consuming and costly.

v. Form sizes should be designed so that they are the maximum size which can easily be handled by hand or by a mechanical lifting device.

vi. The design of the formwork units should be such that they can easily be assembled and dismantled without any being trapped.

Also the Occupational Safety and Health Act (OSHA), states that the general requirements of formwork are as follows:

i. Formwork shall be designed, fabricated, erected, supported, braced and maintain so that it will be capable of supporting all vertical and lateral loads that may reasonably be anticipated to be applied to the formwork without failure.

ii. Drawing or plans including all revisions for the job layout, formwork, working deck and scaffold shall be available at the jobsite.

2.22.7 Factors to be Considered when Designing Formwork

According to Hurst (1983), the factors to be considered when designing formworks are enumerated below.

i. Pressure on formwork.
ii. Concrete density.
iii. Height of discharge.
iv. Temperature.
v. Consistency of concrete (workability).
vi. Live loads and wind pressure.
vii. Vibration.
viii. Hydrostatic pressure and pressure distribution.

2.22.8 Lateral Pressure of Concrete on Formwork

According to Peurifoy and Oberlender (2005), the pressure exerted by concrete on formwork is determined primarily by several or all of the following factors.

i. Rate of placing concrete in forms.
ii. Temperature of concrete.
iii. Weight or density of concrete.
iv. Method of consolidating the concrete.
v. Depth of placement.

The American Concrete Institute (ACI) recommends that formwork designed for its full hydrostatic lateral pressure are given by the following equation:

$p = wh$

Where p = lateral pressure, N/m^2

w = unit weight of newly placed concrete, N/m^2

h = depth of the plastic concrete, m

For concrete placed rapidly such as columns, h should be taken as the full height of the form.

2.22.9 Design of Formwork

According to Peurifoy and Oberlender (2005), forms for concrete structures must resist the pressure to which they are subjected and support the load imposed on them. In order to assure adequate strength and rigidity consistent with maximum economy, forms must be designed with the same care and engineering principles that are used to design the permanent members of the concrete structures. Selecting the sizes and spacing of form members by assumption, or by guess, is unsatisfactory and can be very dangerous. Under-designing can result in the failure of the forms and over designing will result in excessive costs. In order to design forms properly it is necessary to have certain basic information. This include a knowledge of the pressure produced by, or the weight of the concrete on, the forms including both static and dynamic forces, as well as a knowledge of the physical properties of the materials uses for the forms.

More often than not, contractors tend to mould anything on site to be used as formwork to hold wet concrete regardless of the fact that in designing formwork, adequate care must be exercised for the right size and shape of the form system if the designed concrete structure

is to be achieved. To resize this, the designer must have certain basic information to aid him. This includes the pressure produced by the weight of concrete on the forms including both static and dynamic forces. Also the designer must have knowledge of the physical properties of the materials for the forms and the environment in which it is to be used.

The intensity of pressure on the wet concrete increases with its thickness of depth and the points of maximum pressure occurs at the bases of walls, beams and columns. Hence, errors in formwork design is likely to cause distortion or failure at the bases of most concrete structures and this ultimately lead to collapse which may affect all parties involved as well as third parties (the contractor, the client, etc).

The selection of sizes and spacing of formwork members by assumption is unsatisfactory as well as dangerous. Therefore when designing care should be taken to avoid the under-designing of forms since this may cause failure and over-designing which will also call for excessive cost.

It is therefore the responsibility of the designer of formwork to see to the conditions at each jobsite and be able to determine the right analysis and design equations. It is important to note that the procedure for designing must comply with all code specifications and regulations governing the design and use of formwork.

2.22.10 Design and Planning of Timber Formwork

According to Steele (2001), the system of formwork should be designed by a competent engineer in accordance with relevant regulations, guidance and codes of practice.

The design should clearly state the method and sequence of erecting and stripping of formwork, the number of re-use cycle and the sequence of replacement should be checked

by another competent engineer, independent of the original designs before the implementation of formwork.

The system should be designed to support the weight of the formwork and concrete and other additional live loads such as pumps, workers, mixers and pouring of concrete. Alteration and addition should be approved by the designer in writing before the works commence. All drawings, specifications and associated documents should be presented in a way that is easily understood by persons erecting or stripping of the formwork system and should be available for inspection at the site.

2.22.11 Erection

According to Wilshere and Telford (1992), formwork should be erected safely and constructed in accordance with the approved drawings, specifications, method statement and any other associated document. Formwork should be erected by persons who have received appropriate training relevant to the system being used.

All substandard materials or damaged components for both formwork and falsework should not be used. Workmanship should be controlled to ensure that the final concrete structure is completed within the limits of acceptable dimensional tolerances and satisfied the finish requirements. Precautions should be taken to prevent dislodgment of any part of the formwork system arising from inclement weather. Ground conditions, where the formwork system is to be erected, should be checked and made stable.

2.23 Inspection and Concrete Placing

According to Johnson and Wheeler (2005), inspections should be conducted prior to and during the placement of concrete to ensure the formwork is constructed according to the drawings, specifications, method statement and associated documents.

Critical and heavy falsework should be inspected and certified by a competent engineer before it is loaded / struck off. Where appropriate, independent inspection would be done by an independent consulting engineers when necessary.

The formwork system and falsework should be inspected and certified by the competent engineer after any alteration and addition.

The materials such as joists, bearers, plywood, support frames and U heads should comply with the specifications and relevant codes and should be used in accordance with manufacturers' recommendations.

All timber structural members such as joists, beams or waling should comply with the grade stress as specified by a competent engineer.

All timber structural members should be checked to ensure that no timber with longitudinal joints or cracks is used and any damaged /deteriorated formwork panels should be replaced.

The gap between formwork panels should be checked and kept to the practically acceptable minimum, to avoid cement grout loss.

Inspections should be conducted after a typhoon, heavy rainfall and flooding to ensure the system of formwork and falsework are stable and safe at all stages.

Full records of inspection and re-inspection should be kept in the site office and remain available for reference when necessary. Placement of concrete should be carried out by skilled workers.

Concrete should be placed consistently and overloading should be avoided.

For cantilever structures, concrete should be placed on the inboard part of section before proceeding to the cantilever.

2.24.0 Stripping of Timber Formwork

According to Peurifoy and Oberlender (2005), at the time the detail for making forms are prepared, the order and methods of stripping should be considered. Unless care is exercised in making and erecting forms, it may be discovered that some parts, panels or members cannot be removed without wholly or partly destroying them. Since many panels are to be removed and reuse, it is important to erect them in a manner that will permit their removal without damage. Parts or panels that are to be removed first should not be placed behind others that will be removed later. Such parts should be fastened together with double-headed nails which can be removed easily.

Stripping of formworks must be undertaken in accordance with the drawings, specifications, method statement and associated documents.

Stripping of formwork should comply with the Building (Construction) Regulations and should not be commenced until the permanent structure has attained sufficient strength and special conditions, if any, are noted and observed. All stripping works should be carried out in a safe manner and should strictly comply with safety requirements and procedures that is planned and controlled systematically throughout the whole process. All persons carrying out the stripping works should have received appropriate training.

Stripping of formwork and falsework should be carried out in a manner that ensures the gradual transfer of the load from the formwork to the permanent structure. All formwork panels after stripping should be thoroughly cleaned and free of cement paste before re-use.

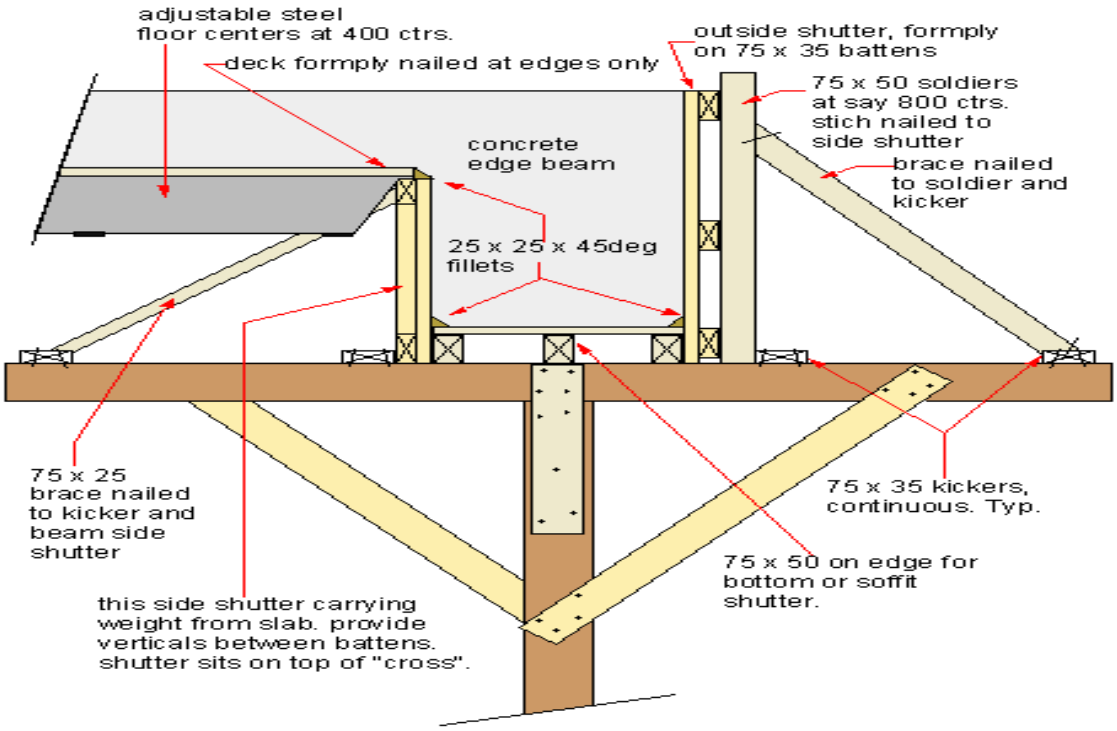

FIG.2.2. Details of Beam and Slab Timber Formwork

Source: Desch (1980).

2.24.1 Advantages and Disadvantages of Timber Formwork

Advantages

According to Peurifoy and Oberlender (2005), the following are the advantages and disadvantages of timber formwork.

i. It is economical for small construction jobs.

ii. It is design flexible and easy to erect.

iii. It has good thermal insulation which makes it useful to be used in colder regions.

iv. It can easily be made into any shape or size.

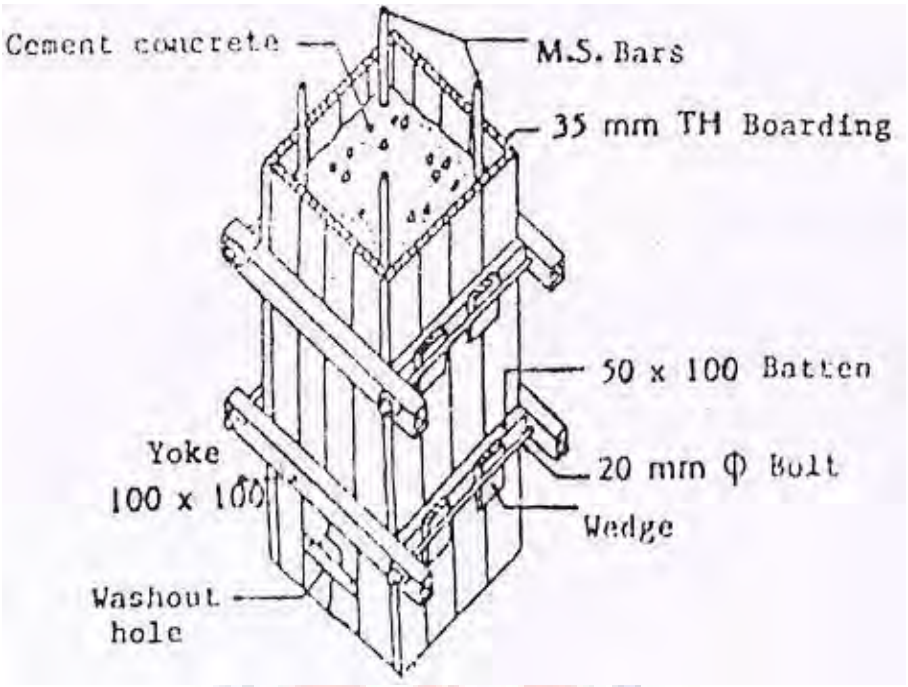

FIG. 2.3. Details of Column Timber Formwork

Source: Building Technology Vol. 2. Chudley (1997).

Disadvantages

i. Poor finish patching almost demanded if in a place where finished concrete will be seen.

ii. Low per unit use (10 – 12 max).

iii. High labour as each set must be “re-built”.

iv. Must wait till concrete is well set (24 hours) to strip.

v. Leaves a dusty finish as there are sugars in the sap of soft woods.

vi. More waste is generated.

vii. The timber cannot be recycled and less sustainable.

2.24.2 Economy and Cost of Formwork

Economy in formwork begins with the design of a structure and continues through the selecting of form materials, erection, stripping, and the levels of re-use of forms.

Peurifoy and Garold (1996), states that the cost of forms include equipment required to fabricate and handle the forms. Therefore any practice that will reduce the combined cost of all these items will save money to affect economy in formwork; the following procedures must be adhered to;

i. Design the form to provide the required strength with smallest amount of materials.
ii. The most number of re-use.
iii. Do not specify or require high quality finish on concrete surfaces, which will not be exposed to public view.
iv. Consider the sequence of stripping when planning forms.
v. Make use of prefabrication where possible.
vi. Use patented form panels and other patented members, which are often less expensive than form build on site.
vii. Create a cost of material consciousness among the carpenters who make the forms.

To be able to calculate the cost of formwork of a particular contract, the following information must be known.

i. Description and quantity of formwork to be used.
ii. Formwork drawing with schedules of materials.
iii. Phase drawings showing the number of uses.
iv. Programme.
v. Feedback of labour constant.

Wong (1999), however states that information on cost of formwork in relation to total cost of construction will be appreciated to enhance a system of controlling this cost to be instigated if the construction company or formwork specialist is to remain competitive.

It is not enough to plan and construct a good system of formwork and then have the question of control to chance. Hence to be successful the whole processes of manufacture from the beginning to completion must be properly controlled.

The benefits of efficient formwork include job site productivity, improvement in safety and a reduction in the occurrence of errors.

2.25.0 How Waste is Generated From Timber Formwork

According to Building Research Establishment Digest Vol. 4 (1983), the usage of timber can be hardly being ruled out in all aspects of building construction works. It is, perhaps, the most important building material in the construction industry. It is used almost at every stage of the construction of every building, that is, from the preliminary stages to the finishing of the project. Apart from being used for finished products in buildings, timber is also used mostly for all temporary works such as formworks scaffolds, earthwork supports and props and shores.

However, as important as it is timber does not come cheap. Large sums of money go into the purchase of timber mostly for preliminary works. It is estimated that about 75% of the estimated cost of timber for the construction of a building go into purchase of timber meant for temporary works. This notwithstanding, a walk around most construction sites makes one wonder whether the timber meant for temporary works on site were really bought. This is because of the way pieces of this timber are strewn all over the site as though there were no use for them. What we see today are clear manifestations of timber wastage, where most

of these timbers go to waste. This may be due to some associated problems, which could be classified as either natural or human causes.

According to Botkins (2013), due to depletion of our natural resource (the forest), there have been increasing causes for concern over the destruction of our forest. These have brought about the growing awareness that there is the need to protect our forest. For we must remember, “If the last tree dies, the last man dies”

Timber is arguably the most remarkable structural material on earth. With the passage of time, studies have revealed the diversity of this material. It is estimated that there exists over 20,000 different species of trees in Ghana, and thus, potentially, a similar number of different kinds of timber. Although, those of commercial importance may number only a few hundreds, the range of anatomical structure and chemical and physical properties that they display in nonetheless most striking. Thanks to its readily availability, people have found timber to be an effective material to work with, and we continue to use it in vast quantities.

However, we must bear in mind that, unlike many other constructional materials, timber can never be manufactured so the best use has to be made of the already available one. The more the timber that is used, the more trees that are felled and thus the more the depletion caused to our forests.

Wastage of timber in the construction industry is considerable; the overall loss is about 100% more than is usually anticipated or allowed for in estimating and technical accounting conventions. This figure, though high, is variable and in some areas much lower. Wastage of timber occurs at all stages of its handling on site, from the time of its

arrival on site, through stacking, fixing and seasoning to utilization. These major factors contribute to wastage of timber on the construction site.

Wong (1999), argues that though timber wastage is a natural occurrence and inevitable, since the usage of timber can never be ruled out in many constructional activities, studies have shown that this wastage can be brought to the barest minimum when effective measures are taken. As volatile as it is, timber, which is very much prone to so much damage is not effectively utilize on most construction sites. This study seeks to investigate into how timber meant for temporary works can effectively be utilize on construction sites, thereby minimizing wastage and making savings on both money and depletion of our forests.

The problem associated with the use of timber meant for temporary works in most cases eliminate the many advantages which timber possess as a constructional material over other materials.

Such problems when not attended to early enough may tend to have serious repercussions on the level of waste generated from the usage of timber. These problems may also affect the estimated cost of construction, which in the long run adversely affect the overall cost of execution of a project. These problems can be classified as either naturally caused or by human causes.

2.25.1 Natural Causes of Wastage

Seeley (1995), states that natural causes of wastage are those, which impair the timber naturally. They normally cause defects in the timber by causing a variety of defects, which may make it impossible for the affected timber to be effectively utilized.

The types of wastage are:

i. Natural defects in timber.

ii. Fungal attacks; wet or dry.

iii. Dimensional movement due to temperature and moisture movement.

2.25.2 Human Causes of Wastage

Building Research Establishment Digest Vol.4 (1983), states that these are the types of causes, which impair the timber after they are felled. They are caused by human activities and normally during the processing of the felled timber. The human causes aid wastage of timber in so many ways and different forms and can occur in any stage of the processing of the felled timber to it final disposition.

Such causes could result in the total loss of the whole timber and might not be recovered again. The types of wastage are:

i. Conversional waste.
ii. Transport and delivery waste.
iii. Preservation and storage waste.
iv. Utilization waste arising from cutting, fixing, learning waste, application and residual waste.
v. Supervision and / or management waste.
vi. Waste arising as a result of vandalism or theft.
vii. Waste due to deliberate or accidental overloading.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

Manning and Cullum-Swan (1994), states that research methodology is a documented process for management of project that contains procedures, definitions and explanations of techniques used to collect, store, analyze and present information as part of research process in a given discipline .

This chapter presents an outline of the methods and techniques for the design instrument and collection of data for research. This includes the research design, the population of the study, sample and sampling technique, research instrument, data collection procedures and the data analysis.

3.1 Research Design

This study adopts a quantitative research method. The rationale for the choice of a qualitative approach stems from the nature and context of the study. According to Denzin and Lincoln (1994), quantitative research is used when researchers seek to understand the context of the research matter in terms of how and why it occurs and when the research fact is emergent rather than prefigured.

The features present in this study, is an exploratory study providing an in – depth investigation to supply evidence of the user's perceptions. This involved the researcher physically inspecting and surveying the areas of study to obtain primary information and some basic information for the research. The quantitative research design is in the form of inductive naturalistic enquiring and is part of the conceptualizing process, namely conceptual framing or grounded theory.

3.2 Population of the Study

The research was intended to involved as many as possible stakeholders in the construction industry as far as formwork is concerned. The study was undertaken by seeking information from construction companies. In order to obtain a reliable information of formwork, it was decided to collect the data when timber is brought to site, during its usage and afterwards.

55 construction companies were selected in the metropolis. 25 (46%) were class A construction companies, 10 (18%) pre-cast concrete manufacturing companies and 20 (36%) medium and small scale construction companies.

3.3 Sample and Sampling Procedure

This research used the random method of sampling. To help achieve the purpose of the study, a number of respondents were contacted on their construction sites and offices. These respondents comprised of 10 (18%) foremen, 12 (22%) general foremen, 15 (27%) supervisors and 18 (35%) site engineers.

3.4 Research Instrument

The research instrument designed for collection of the data for the study was questionnaires, interviews and observations.

3.4.1 Questionnaires

Sommer and Sommer (1991), states that a questionnaire is a series of written questions on topic about which the respondent written opinions are sought. Because it is so economical to administer and score, the questionnaire is widely used in behavioural research.

Open-ended questions provide space for the respondent to write in their own answers, [see appendix A (vii to viii)]. With closed or multiple-choice questions, respondent choose from

among alternative provided by the researcher [see appendix A (ii to vii)]. Open-ended questions are desirable when the researcher does not know all the possible answers to the question, when the range of possible answers is so large that the question would become unwisely in multiple-choice format, when the researcher want to avoid suggesting answers to the respondent own words. Multiple-choice answers are desirable when there is a large number of respondents and question, when answers are to be scored by computer and when answers from different groups of individuals are to-be compared.

Converse and Pressers (1986), refers to the importance of issue in people minds. Open-ended question are well suited to determine by asking the respondent to rank or rate a list of answers in terms of importance.

In many cases you will need a middle-response category such as neutral" or "undecided," and need to include a non-applicable" or "don't know" response.

Check all items for clarity. Avoid double-barreled and negative question. Provide balance. Always pretest the questionnaire before putting it into final form.

Labaw (1986), infers that the questionnaire is of little importance with respondents who are very young, very old, infirm, or uninterested in the topic. The typical questionnaire with multiple-choice answer evokes "bare bone" response. Questionnaires are more successful in identifying attitudes than in predicting behaviour.

3.4.2 Interviews

Rubin and Rubin (1995), makes the distinction that the quantitative interviewing design is flexible, iterative and continuous rather than prepared in advance and locked in stone.

Design in quantitative interviewing is iterative. That means that each time you repeat the basic process of gathering information, analyzing it, winnowing it, and testing it, you come

closer to a clear and convincing model of phenomenon you are studying. The continuous nature of quantitative interview means that the questioning is redesigned throughout the project.

Babbie (1999), reiterates that the quantitative interview in an interaction between an interviewer and a respondent in which the interviewer has a general plan of inquiry but not a specific set of question that must be asked in particular words and in a particular order. It is essentially a conversation in which the interviewer establishes- a general direction for the conversation and pursues specific topics raised by the respondent. Ideally, the respondent does most of the talking.

32 (58%) out of 55 construction companies were interviewed on one-on-one basis and given questionnaires to answer. However, 20 (63%) of respondents did not have ample time to answer the questions (21-34) and therefore have to resort to personal interviews.

3.4.3 Observations

According to Sommer and Sommer (1991), observation can be done in two ways which are casual and systematic observation.

Casual observation: It is done without prearranged categories or scoring system. This refers to eyeball inspection of what is happening. It is most useful at early stage of the research or as an accompaniment to some other procedure.

Systematic observation: This type of observation employs a scoring system and prearranged categories that applied consistency. This usually require and observation checklist, on which information is recorded under the proper heading categories on the checklist should include those items of behaviour that occur naturally in the situation and can be observed and recorded.

The data collection instrument was used because it is the best through which accurate information could be elicited in a study of this kind where the variable under investigation requires statement of facts and personal opinions. Also, in the environment where both telecommunication and postal services are reliable, this method was considered to be the most effective in generating a high response and participation rate and opportunity for feedback. Respondents had to tick the appropriate column or select from the alternative answers and provide significant information through the few open ended questions.

The questionnaire starts with general questions regarding issues relevant to the participants. The purpose of these questions is to allow the participants to freely answer the questions, raising their own ideas and reduce the risk of response bias, Denzin and Lincoln (1994), cited in Marriott (1974). They were also intended to gather important like the level of education and profession of respondents (a very useful piece of information peculiar to the study).

3.5 Data Collection Procedure

According to Yin (2003), the field of qualitative research has six forms of sources of evidence for the collection of data. The six forms are documentation, archival records, interviews, direct observation, participant observation and physical artefacts. Documentation is important for almost every case study. Document can be letters, memoranda, agenda, newspapers and articles in mass media or community news letters. In case studies, documentation is used to confirm argument evidence from other sources. General information about formwork can be found at the websites. General information about timber and steel formwork can be gotten from text books. Interviews are a narrative

method of collecting data. The interview consists of two or more participants that engage in a conversation that constitutes a learning process.

The purpose of the interview was to show clearly what is going on in the construction sites. The better grasp of the research purpose, interviews provide a more in-depth into the research area. By interviewing, the researcher is limited to fewer information with rich information sharing. The interview is the most important source when it comes to obtaining information within a case study.

The questionnaires were personally distributed by the researcher in different construction sites and offices. By this procedure the researcher was able to retrieve 32 (58%) out of the 55 questionnaires from the construction companies. The data collection procedure enabled the researcher to have personal interaction with some of the respondents and explain the significant of the study to them and also some of the issues on which their understanding were clouded. Also, the informal interactions offered vital information which gave the researcher better insight into the prevailing conditions.

3.6 Data Analysis

Yin (2003), explained, a case study should start with a general analytical strategy that provides the basis for what to analyze and why. Analyzing quantitative data is about examining, categorizing, tabulating and recommending the empirical evidence to address the initial propositions of the study. The purpose of analyzing quantitative material is to make the material more clear and distinct, making sure not to lose the extent of information that the material includes.

There are different general analytical methods, relying on theoretical propositions, thinking about rival explanation or developing a case description. Yin (2003), further explained that

without a general analytic strategy, a case study will be difficult to carry out. According to him the first strategy, relying on theoretical proposition is most preferred. It means that you are following the theoretical propositions that lead to your case study. The original objective design of the case study presumably was based on such propositions, which in turn reflected a set of research questions, review of the literature and new hypothesis or propositions. The response from the research were tallied and tabulated according to the items on the various sections. The results obtained were recorded and put in percentages using table and chats provided in each section. Analyses were presented in a descriptive statistical format using the mean score. Discussion and interpretation were then made.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter presents and analyses the data obtained from the research conducted, by evaluation of the comparison between the uses of timber and steel formworks in the constructional industry of some selected companies in the Greater Accra Metropolis.

A quantitative approach was applied in analyzing the data. Data gathering was analyzed statistically using simple percentage in the tabular form.

4.1 Presentation of Results.

Questionnaires.

Questionnaires to construction companies in the Accra Metropolis.

Table. 1. Results of Questionnaires

No.	QUESTION	RESPONSE	FREQUENCY	PERCENTAGE (%)
1	How long have you been in the construction industry?	1-5 years	4	12.50
		6-10 years	8	25.00
		11-20 years	8	25.00
		Over 20 years	12	37.50
2	How do you classify your firm under enterprises?	Sole trader	16	50.00
		Limited liability	8	25.00
		Partnership	8	25.00
3	What type of construction activity are you engaged in?	Estate development	16	50.00
		Factories	4	12.50
		Educational buildings	10	31.25

		Commercial buildings Hospitals and clinics	2 0	6.25 0
4	What percentage of project expenditure is spent on timber formwork for temporary works?	0-10% 11-20% 21-30% Over 30%	24 8 0 0	75.00 25.00 00.00 00.00
5	Do you have a woodwork [carpentry] department?	Yes No	24 8	75.00 25.00
6	How skilled are your personnel?	Skilled Semi-skilled Unskilled All the above	8 12 4 8	25.00 37.50 12.50 25.00
7	Who does the purchasing of timber?	Head of the woodwork department. Purchasing officer Other specify	24 8	75.00 25.00
8	Where do you obtain your timber?	From the mills From the market Both mills and market Other specify	8 8 16 0	25.00 25.00 50.00 00.00
9	What method of seasoning is used?	Natural Artificial No seasoning is required	4 0 28	12.50 00.00 87.50
10	Is the seasoning done as	Yes	2	6.25

	required /necessary?	No	2	6.25
11	Is the timber well treated and preserved?	Yes No No treatment and preservation	4 0 28	12.50 00.00 87.50
12	How do you store timber meant for formwork?	Direct on the ground in an open area On raised platforms in an enclosed area Other specify	28 4 0	87.50 12.50 00.00
13	What is the level of waste generated from timber formwork?	Low Moderate High Very high	0 0 4 28	00.00 00.00 12.50 87.50
14	What is the main cause of waste generated from timber formwork?	Deliberate Accidental Normal causes Other specify	4 8 20	12.50 25.00 62.50
15	What measures have you put in place to minimize wastage of timber used for formwork in your firm?	By education By strict supervision Adopting new materials Other specify	8 8 16	25.00 25.00 50.00
		STEEL FORMWORK		
16	How long have you been using steel formwork?	1-5 years 6-10 years 11-15 years 16-20 years	10 8 6 6	31.25 25.00 18.75 18.75

		More than 20 years	2	6.25
17	Which part of the building do you use metal formwork?	Foundation Columns Beams Walls Slabs All the above	0 12 6 6 6 2	00.00 37.50 18.75 18.75 18.75 6.25
18	What percentage of project expenditure is spent on steel formwork in general?	0-10% 11-20% 21-30% Over 30%	30 2 0 0	93.75 6.25 00.00 00.00
19	How do you acquire your steel formwork?	Locally manufactured Imported Both locally and imported	6 12 14	18.75 37.50 43.75
20	Is iron ore mined and smeltered in Ghana?	Yes No Only mined I do not know	2 12 12 6	6.25 37.50 37.50 18.75

4.2 Summary of Analysis of Questionnaires on Timber (1 – 20)

Question 1

According to the summary on how long the companies have been in the construction industry, 62% of the companies have been in the industry for more than 10 years.

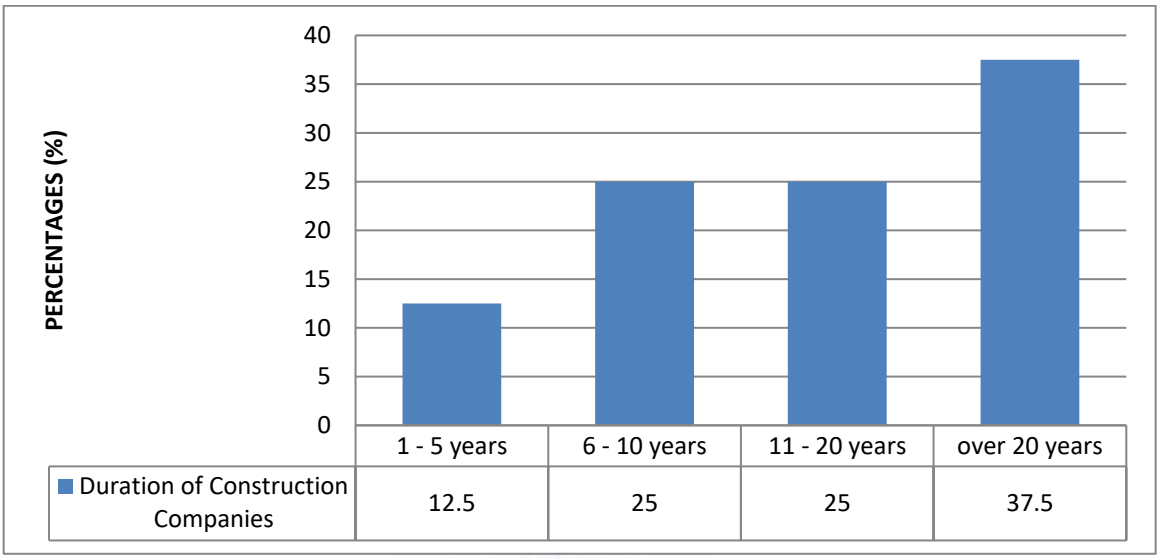

Fig. 4.1 Duration of Construction Companies

Question 2

50% of the enterprises are sole traders and the remaining forms 25% each.

Question 3

The survey further depicts the type of construction activities engaged by the construction industries is estates development 50%, followed by educational buildings with 31.25% of the total survey, factories is the next activity with 12.5% and commercial buildings, 6.25%.

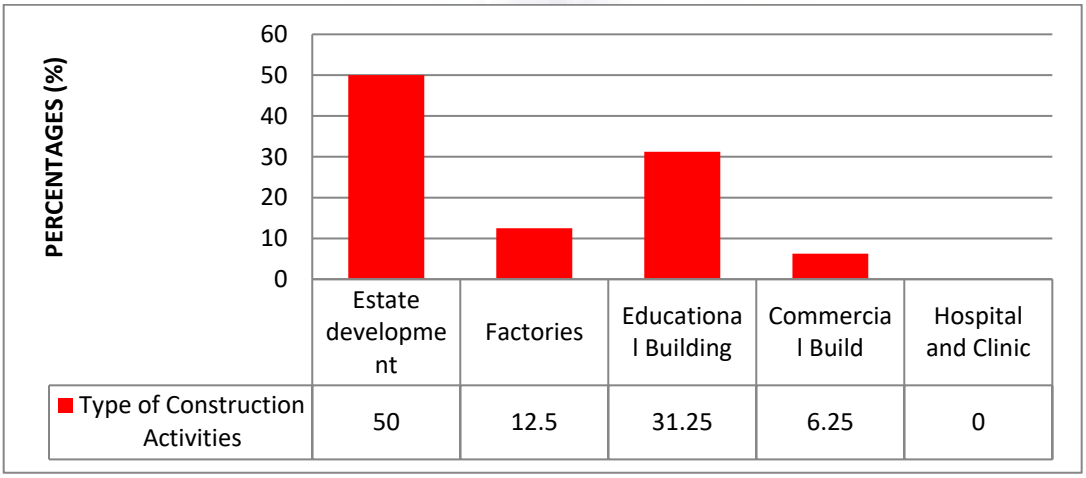

Fig. 4.2 Types of Construction Activities

From the survey, it was established that 75% of the companies spend between 0 to 10% of project expenditure on timber formwork whilst 25% of the remaining companies spend between 21 – 30%.

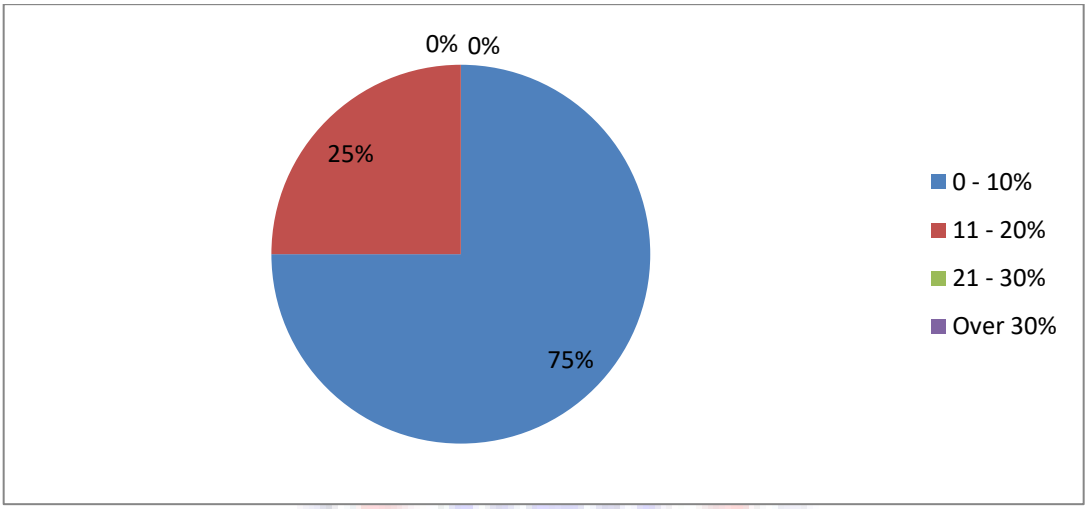

Fig. 4.3 Percentage Project Expenditure on Timber Formwork

Question 5 & 6

The survey further revealed that 25% of the companies have woodwork department. These companies have all kinds of personnel with the semi-skilled labour being the highest (37.5%). Skilled labour is 25%, unskilled labour is 12.5% each, and all the rest above 25%.

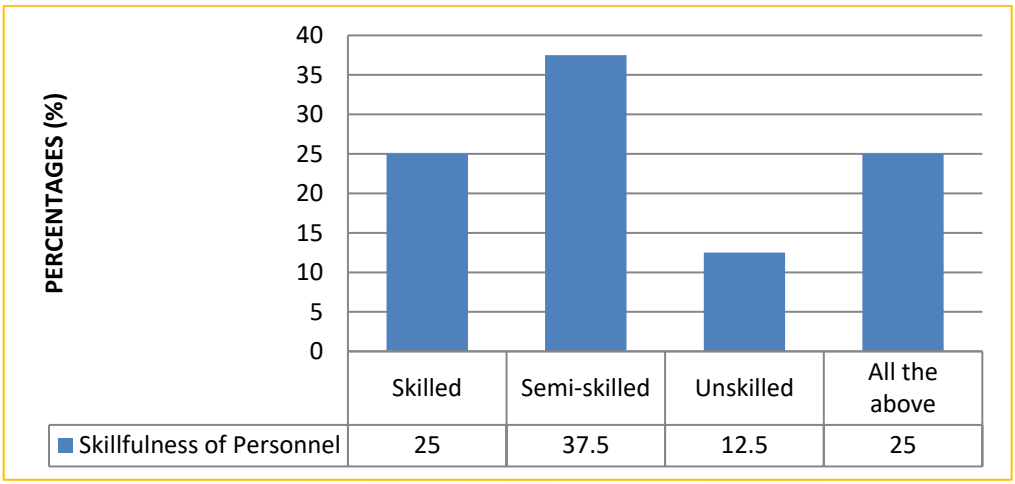

Fig. 4.4 Skillfulness of Personnel

Question 7 & 8

75% of the companies confirmed that the head of the woodwork department purchases the timber and the remaining 25% is done by the purchasing officer. 50% of the companies confirmed that timber is obtained from both mills and man heat. The remaining percentage is shared equally from mills and market.

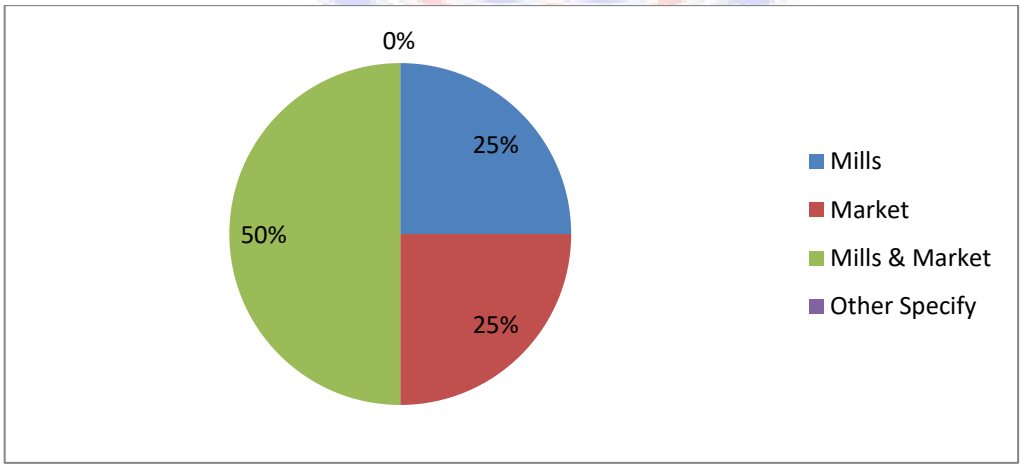

Fig.4.5 Sources of Timber

Question 9 & 10

The survey also revealed that 12.5% of the companies use natural seasoning and 50% out of this seasons the timber as required.

Question 11 & 12

88% of the companies does not preserve the timber nor stack on raised platforms.

Question 13, 14 & 15

Waste generation on timber is very high (87.5%), about 62.5% is by normal causes and the remaining 37.5% are deliberate and accidental. Measures put in place to reduce wastage, 50% is by adopting new materials eg. Steel, and the remaining percentage is by education and strict supervision.

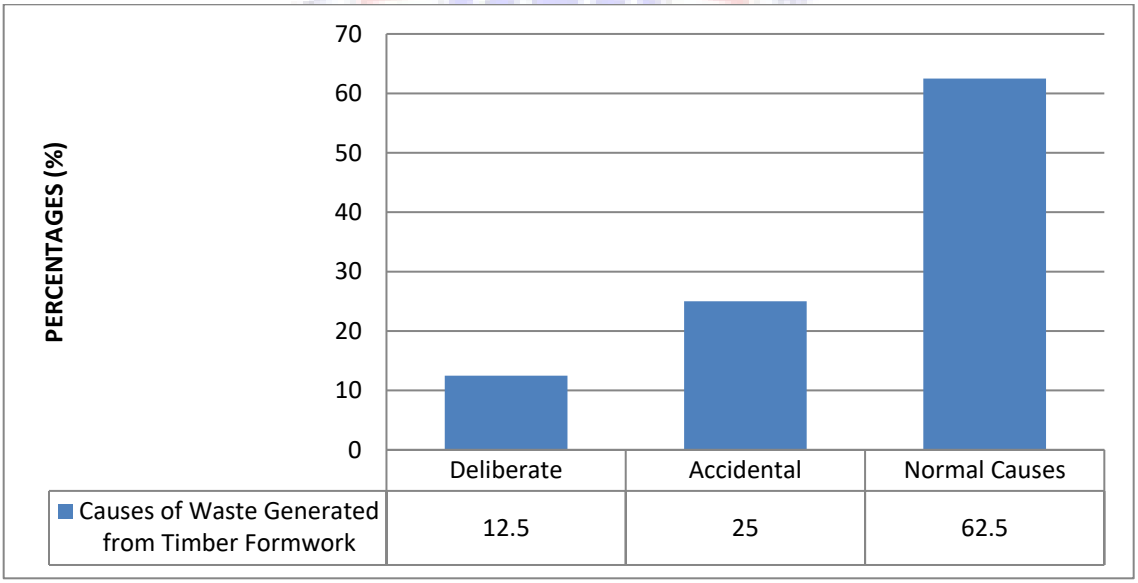

Fig. 4.6 Causes of Waste Generated from Timber Formwork

4.3 Summary of Analysis of Questionnaires on Steel

Question 16

From the results of the survey, it was established that steel formwork has been used massively in the past two decades. 69% of the companies have been using steel for more than 6 years.

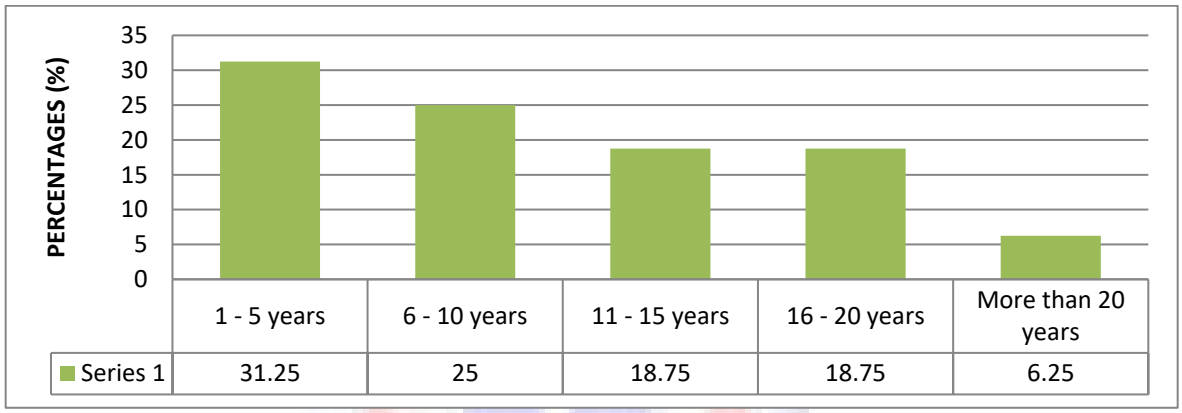

Fig. 4.7 Duration of use Steel Formwork

Question 17

It was further deduced from the survey that metal formwork can be used on all parts of the building with the exception of the foundation with usage high in columns (37.5%) and beams, slabs and walls form the remaining percentage.

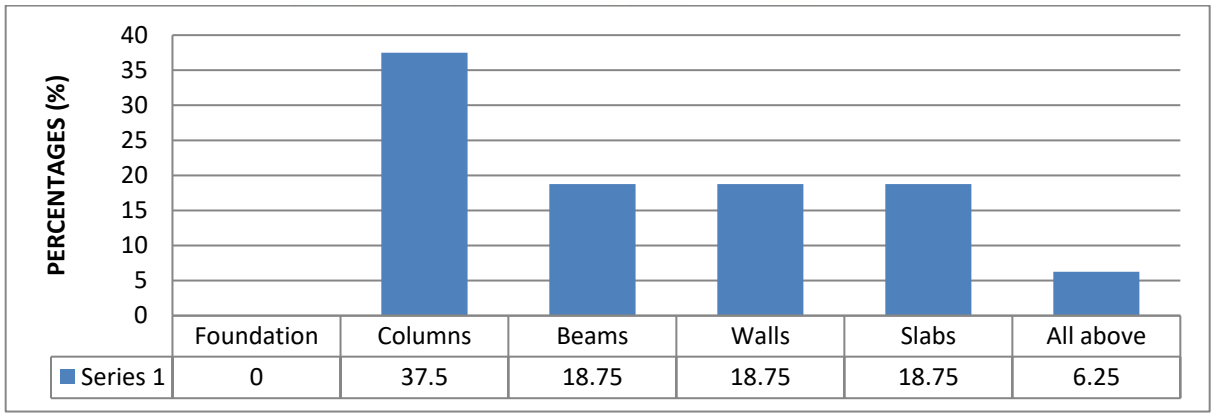

Fig. 4.8 Positions where Steel Formwork is used

Question 18

It was established from the survey that 94% of the companies spend between 0 – 10% of project expenditure on steel formwork whilst the remaining percentage is between 11 – 20%.

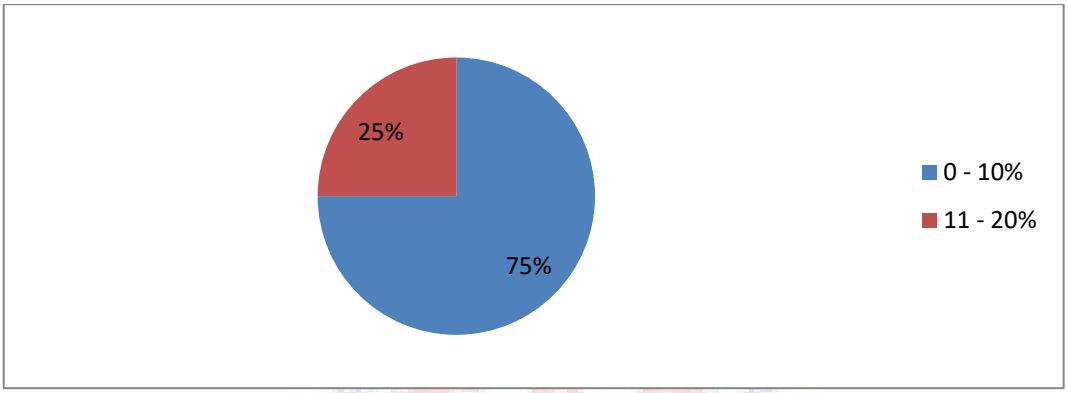

Fig. 4.9 Percentage Project Expenditure on Steel Formwork

Question 19

The survey revealed that both locally manufactured and imported forms 43.75% of the companies, imported 37.5% and locally manufactured 18.75%.

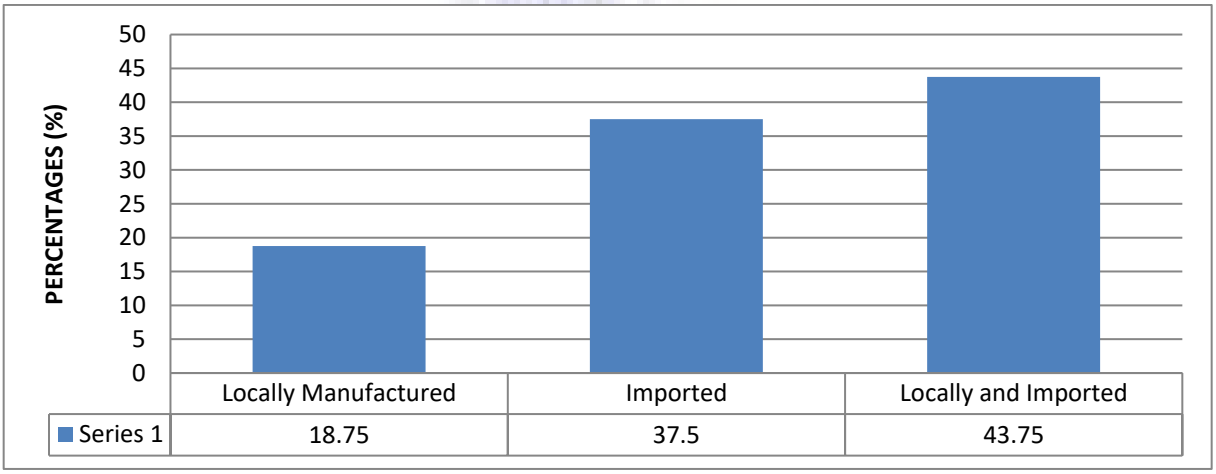

Fig. 4.10 Acquisition of Steel Formwork

Question 20

About 62.5% of the respondents are aware that iron ore is mined and smeltered in Ghana, 37.5% are not aware and 37.5% only mined and 18.75% do not know.

Questions 21-34 are personal interviews with respondents. These are general summaries of the interviews. According to the respondents, there was not adequate time to answer these questions in writing, therefore the researcher have to adopt this method.

Question 21

What are the advantages of steel formwork over other materials like timber, panels (plywood) and aluminium in terms of cost?

About 80% of the respondents were of the view that the overall cost of steel formwork is very low: less labour costs, time saving, increased speed of erection as compared to timber, plywood panels etc.

Question 22

How do you maintain the steel formwork?

All the respondents agreed that maintenance of steel is quite easy. They are generally maintained regularly after usage by removal of grout and concrete. This is achieved by application of mould oil or release agent in the formwork that comes in direct contact with concrete. Other parts of the formwork with joints like struts, props, sole pieces and plates are cleaned regularly and oiled or greased depending on the situation.

Question 23

How do you transport and stack steel formwork on the site before and after use?

About 65% of the respondents have improvised their own system of transporting steel formwork whiles the remains 35% who hires the formworks provides or hires trucks to

transport them. Steel forms are transported according to the members and sizes. Struts pieces and plates are transported separately in trucks. The moulds made up of steel sheets and boxes are brought in separately. They are stacked on wooden platforms above ground level preferably under a shed so that they are not damaged by the weather before and after use.

Questions 24

What factors do you consider when choosing steel formwork?

The number of respondents who agreed on the following factors in percentage are as follows:

- The cost is 100%.
- Number of uses is 90%.
- Speed of erection 85%.
- Sustainability and reliability 80%.

Question 25

From the use of forms over the years, which types(s) of formwork offer(s) the most desire finishing and why?

Almost all about 95% of the respondents agreed that steel forms provides the best prescribed finishing because it does not stick to the concrete surface, it provides very smooth surface and therefore no need for rendering and plastering.

Question 26

How would you compare timber and steel formworks in terms of quality of work, labour, speed of erection and striking and strength?

About 85% of the respondents agreed that steel formwork provides very high quality of work, less labour requirements (semi-skilled labour can be employed), high speed of erection and striking of forms and provides greater strengths to support concrete and any other working load than timber formwork.

Question 27

How would you compare timber formwork and steel formwork availability?

Steel formwork is not readily available as compared to timber forms which is in abundance and available everywhere. 95% of the respondents confirmed the availability of timber than that of steel. Sometimes contractors have to rent the steel props, struts, braces, sole pieces and plates. The moulds have to be formed by cutting steel sheets and welding them together.

Question 28

What are the levels of reuse of steel formwork?

80% of the respondents accepted that steel formwork can be reused for more than two hundred times especially props, struts, braces, sole plates etc. The remaining 20% were not sure because the steel formworks were always rented. The moulds can also be reused likewise especially in the precast concrete manufacturing companies where standard sizes are concerned.

Question 29

Can steel formwork be recycled or reused for other purposes?

Yes, 80% of the respondents confirmed that steel can be recycled or reused for so many purposes when it deteriorates and the remaining 20% were not sure because the steel formwork were always rented. This can serve as an additional income to the constructor

when deteriorated steel are sold to scrape dealers and reduce the nation dependent on imported steel. It can also be used for roofing sheets, structural steel, iron rods, pipes, angles etc.

Question 30

Does it pose any threat to the environment through these processes?

About 60% of respondents were not sure of the threat to the environment. The remaining 40% agreed that they do not know about any threats to the environment..

Question 31

Is iron ore mined and processed in Ghana?

Only 10% of the respondents confirmed the mining of iron ore in Ghana. 90% the respondent do not know about mining and processing of iron ore in Ghana.

Question 32

How do you compare logging and iron ore mining creation of environmental degradation, to plants, animals and indigenous people.

About 80% of the respondents confirmed that they are not sure of environmental degradation of logging and iron ore mining to plants, animals and indigenous people. The remaining 20% do not know about environmental degradation of logging and iron ore mining.

Question 33

What advice would you give to the government on the use of timber and steel as far as sustainability of these materials are concerned?

About 65% of the respondents agreed that steel temporary supports such as props, braces, sole plates and struts should be used instead of timber. The remaining 35% did not agree

with this assertion. 70% of the respondents suggested that the government should come out with a policy of using timber as permanent works more than temporary works and encourage contractors to use steel more than timber formworks. In addition to this, government should give tax rebates or reliefs to contractors who imports steel formworks. As far as practicable both materials could be combined effectively to overcome their disadvantages.

Lastly, all the stake holders in the timber trade must be encouraged to go into timber plantation ventures to regenerate our lost forests and illegal loggers should be punished severely when convicted. Department of Forestry and Mines and Energy to be well resourced to check illegal logging, mining, farming etc.

4.Discussion

According to Hlavacek (2007), formwork systems are one of the key factors that govern the success of a construction project in terms of speed, quality, cost and safety of works. Nowadays, most projects are required by the client to complete at the shortest time possible as a means to minimize cost of capital. For buildings of high-rise nature, the most effective way to expedite works is to achieve very short floor cycle, that is, to have the structure of a typical floor completed in the shortest time. The key to achieve this, again, from the production point of views, is by the use of a set of efficient appropriately designed formwork.

Modern buildings in many occasions can be very complex, either in terms of scale or size of the building, no matter they are high -rise, or horizontally spread, or in terms of architectural or structural design, or to fit for sophisticated building services or other

facilities requirements. The designer use of the right formwork system, as well as the stipulation of the effective resource planning strategy to control and maximize the use of formwork, are again crucial to the overall success of a project. As we know that traditional timber formwork has led to technology and environmental impact from its activities, thus steel formworks have been introduced to reduce those weaknesses of traditional timber formwork.

Irwin and Sibbald (1983), stated that steel has been an important material for the fabrication of both common and special purpose formwork. These are some advantages of steel formwork can both benefit in construction technology and environmental impact forms its activities. Firstly, as we know that the steel formwork has a very high durability and strength. Steel formwork is more durable and has longer lifespan as it is stronger, less susceptible to damage and sturdier than timber formwork. Besides steel formwork provides adequate rigidity and strength so that it can sustain any load and movement without failure where it can be erected, moved and re-erected rapidly, disassembled, and provided suitable handling equipment is available for large sections. Steel formwork also can sustain the big concrete mass comparing to timber formwork therefore it is suitable using heavy construction. A set of steel formwork can be used to complete a building construction and might still be able to be used in other projects. Steel formwork also can be reused many times more than traditional timber formwork. Thus it is more worth to use steel formwork for large and repetitive construction. Besides that, steel formwork also has a high worker ability and efficiency. Steel formwork system can be erected twice faster than the timber formwork system. Thus steel formwork can be erected using modular system clip or screw .Since, traditional timber formwork is time consuming and tedious to be erected as timber

formwork are formed using many small pieces of wood and timber panels. In short by using steel formwork, construction time of project can be reduced because of fast track construction was to use steel formwork.

Wilshire and Telford (1992), also confirmed that steel formwork can produce a better quality concrete product. The steel formwork concrete products will have less disfigurement and irregularities comparing to concrete product of timber formwork. Normally, the steel formwork mould are made in factory, it will follow exactly the design specification. As a result the dimension and alignment accuracy of the concrete products will be assured. The concrete products of steel formwork are smooth and are suitable to concrete finishes such as paint and tiles directly. As well as the problem of an even colour of concrete surface caused by the permeability of timber formwork will be reduced by using the steel formwork because steel is an impermeable material. Because of that no plastering is needed for leveling the uneven surface of concrete caused by imperfection of formwork. Furthermore, steel formwork required less labour force for erecting, re-erecting, and striking the formwork. This is because steel formwork was in frame designed thereby the panels can be quickly and easily for fastened and unfastened. It can be handled as one unit because steel formworks mould are made in factory. On the contrary, both the skilled and the unskilled labour is needed intensively for doing the timber formwork jobs such as cutting the wood or timber and forming the formworks on site. Therefore, comparing to traditional timber formworks, the steel formworks require much lesser of labour force for erecting, re-erecting, and striking the formworks.

Steele (2001), and Wong (1999), agreed that even though, steel formwork might have the high initial cost in the construction project comparing to traditional timber formwork .But

on the other hand steel formwork really can save the cost in the long run. This is due to steel formwork has a high reusability and long life span. Likewise, the wasted steel formwork can be sold for recycling. This cannot only reduce the waste disposal of formwork but also can increase the income of the construction contractor by selling steel formwork for recycling. Besides that, waste steel are scrapped for recycling which less construction waste are produced. The wastage produce by steel are slashes into small amount. Moreover, the recycling of steel can both benefits the environment and contractors as they can earn some extra money from recycling of steel. Steel formwork application help reducing the problem which help to solve the construction waste problem which is so serious nowadays. Metal of steel is a material which is iron that is obtained from nature. However, it only contributes very little or none deforestation or loss of biodiversity comparing to using the materials of timber. Even though metal mining might sometimes cause deforestation but the amount is very little if comparing to logging for timber formworks according to Martins (2012).

The materials of steel are very durable and having a high reusability, hence not much metal mining is needed for steel formwork. Thus, it can reduce the greenhouse effects and the decrease of global warming. In addition, steel formwork moulds can produce any desired concrete shapes as they are cast in factory. The concrete steel formwork mould cast will be having the exact shape and dimension like in order or required and then steel formworks are suitable for any simple shape of concrete moulding from common rectangular shape to circular, ellipse and curved surfaced concrete products, thus steel formwork is a good choice. Steel formworks can produce concrete with correct dimension and smooth surface which is exactly like the designed concrete. But steel formwork is preferable for large areas

of work with standard sizes and simple shape. However for smaller, irregular sizes, complex surface and mould designs timber is more economical. Normally after the timber formwork is used, it cannot be used again for the next timber formwork construction. The timbers are usually burn by the person in charge and this contributes to the pollution of environment such as air pollution that can cause serious health problems for children, pregnant women, and people with respiratory problems. But, if we use steel formwork, it can be reused for many times and recycled when it cannot be used anymore which the steel is melted and used for other application. Therefore this can help to preserve the human health environment. Hence, less open burning will happen on the sites as no timber waste will be produced by steel formwork.

CHAPTER FIVE

5.0 Summary of Findings, Conclusions and Recommendations

This chapter deals with the summary of findings, conclusions and recommendations of the study.

5.1 Summary of Findings

From the study it was found that most companies use steel formwork either partial or wholly. That steel formwork is more effective and has been introduced to reduce those weaknesses of traditional timber formwork.

i. The benefits of steel can be realized in construction technology and environmental impact forms its activities. Steel formwork has a very high durability, strength, longer life span, less susceptible to damage, and sturdier than timber formwork.

ii. Steel formwork provides adequate rigidity and strength, can sustain any load and movement without deflection and failure, can be erected, moved and re-erected rapidly and disassembled. Steel formwork can be reused many times more than traditional formwork of timber and also has the ability to be erected twice faster than the timber formwork system.

iii. Concrete products of steel formwork have less disfigurement and irregularities compared to concrete product of timber formwork. Concrete products of steel formwork are smooth and suitable to concrete finishes such as paints and tiles directly whereas timber formwork is not. Plastering is needed for leveling the uneven surface of the concrete caused by imperfection of formwork. Steel formwork requires less labour force for erecting, re-erecting and striking.

iv. Steel formwork is not liable to insect and fungal attack, adverse weathers like rain, snow etc. which can easily damage timber formwork. Steel formwork needs periodic maintenance by cleaning, greasing and oiling its parts. The initial cost of steel formwork is very high in any construction project as compared to timber formwork but on the other hand steel formwork can save the cost in the long run. This is because it has a high reusability and long life span. It can be sold for recycling as waste or scrap which reduces the handling of construction waste. The recycling both benefits the contractor and the environment. The contractor earns additional income, the environmental degradation is reduced and less timber is felled.

v. Steel formwork application helps reduce construction waste problem which is so serious nowadays. Although iron ore (steel) is obtained from nature, it contributes very little to deforestation and loss of biodiversity as compared to the use of timber as a material for formwork. Iron ore mining might sometimes cause deforestation but the amount is very little as compared to logging for timber. The materials of steel are more durable and have a high reusability; hence not much metal mining is needed for steel formwork. Thus, it can reduce the greenhouse effects and global warming.

vi. Since timber waste cannot be recycled, it is sold to chop-bar operators who use them as fuel for cooking. The smoke generated from this contributes to pollution of the environment with serious health problems for children, pregnant women and people with respiratory problems. Steel waste is melted and used

for other applications. Therefore this can help preserve the human health and the environment.

5.2 Conclusions

From the analysis of the findings, the conclusions are as follow,

i. Most contractors in the Accra Metropolis after careful planning managed to cut down the cost of formwork to values between 0 – 30%. On the reuse level it came out that 80% of the contractors used their forms twice whilst 20% managed to use it four to six times. Steel on the other hand can be reused throughout the life time of the company and still be strong. It was established that timber formwork can be reused at a maximum of fifteen times when it is well seasoned, preserved, painted and stored. It can be concluded therefore that timber formwork has not been fully exploited because they are not taking good care of by adequate seasoning, preservation and stacking.

ii. It was realized that most contractors prefer using steel formwork because it is environmental friendly, strong, rigid, less labour force for erecting, re-erecting, striking the formwork, gives a smooth finish and therefore saving cost on finishes. Also it is easier to maintain and store by applying oil to prevent corrosion and rusting than painting the surfaces and corners of the timber and nailing them.

iii. It was also realized that most contractors prefer buying their own forms. Only few resort to hiring since it is more economical than owning one especially where jobs are repetitive in nature. It was evident that most of the companies did not have formwork specialist and their forms were prepared based on past

experience. Most of the forms are beams, struts, yokes, props, sole pieces and plates etc. Safety measures were considered lightly because of the high strength of steel formwork.

iv. Another important outcome of the research was that using faster and easier formwork system could reduce cost of labour. Using steel formwork, the contractor is able to save cost whilst earning good returns on investment. Waste generated from steel formwork can be sold as scrap and recycled. The contractor earns additional income and saves the environment from degradation.

v. Since steel is more sustainable and recyclable than timber, iron ore mining causes less environmental degradation than logging for timber. When steel formwork is encouraged, global warming and greenhouse effects could be reduced considerably. Fire and smokes from the burning of timber waste on site can reduce health problems in our society.

vi. A further study into improving the performance of steel formwork would be an economic breakthrough to the construction industry.

5.3 Recommendations

The researcher wish to make the following recommendations aimed at improving the merits of timber and steel formworks in the Greater Accra Metropolis as a whole.

i. Contractors should be encouraged to employ engineers to advise them on steel formwork design, preparation and maintenance rather than the use of old fashioned methods of making formwork.

ii. All steel formworks for a project must be well planned before the commencement of any project with drawings and calculation before they are prepared.

iii. Timber moulds can be lined with steel sheets to prolong the life span of the timber forms as well as improve the surface of the finished concrete.

iv. Contractors should invest in the education of their employees to keep abreast with modern day technologies, like computers which has the following advantages:

- Faster planning enhances time being saved.
- Adequate allocation of material components leading to a reduction in material and transport cost.
- Efficient formwork on site enhances a reduction in cost of labour which eventually reduces the total cost of the project.

v. The Contractors Association of Ghana should organize seminars and workshops to educate members about the benefits of steel formwork.

vi. The Forestry Department, Department of Game and Wildlife, Ministry of Agriculture and Ministry of Mines and Energy should organized seminars, workshop and durbars to all stakeholders of the timber, mining and agriculture trade about dangers that their businesses causes to the environment and adopt measures to reduce their effects.

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APPENDIX A (i)

QUESTIONNAIRE

FACULTY OF TECHNICAL AND VOCATIONAL EDUCATION

UNIVERSITY OF EDUCATION, WINNEBA

THE COMPARISONS BETWEEN THE USAGE OF TIMBER AND STEEL FORMWORKS AND THEIR IMPACT ON THE ENVIRONMENT IN CONSTRUCTION INDUSTRY IN GHANA

(A CASE STUDY OF SOME SELECTED CONSTRUCTION COMPANIES IN THE ACCRA METROPOLIS)

EMMANUEL A. ABBEY

Dear Sir/Madam,

This questionnaire is part of the research work for fulfilling the Master of Technology Education in Construction Technology. The aim of this study is to create awareness of using timber formwork as against the use of steel which causes environmental degradation to our nation.

This survey in conducted to collect data and to study the merits and demerits of timber formwork as compared to steel formwork and their impact on the environment in the construction industry in the Accra Metropolis.

All responses will be kept **STRICTLY CONFIDENTIAL AND EXCLUSIVELY FOR ACADEMIC USE.** Only summaries will be publicized. I wish you will consider my request and cooperate, looking forward to your response.

QUESTIONNAIRE (CONSTRUCTION COMPANIES)

Your contribution towards this study is highly appreciated as it will significantly add to the value of this research. Please *tick* (√) within the squares provided to select the answer.

Appendix A (ii)

SECTION A: Background information

Company name:

State your title:

1. How long have you been in construction industry?
    a. 2 years [ ]
    b. 2 – 5 years [ ]
    c. 6 – 10 years [ ]
    d. 11 – 20 years [ ]
    e. Over 20 years [ ]
2. How do you classify your formwork?
    a. Sole trader [ ]
    b. Limited liability [ ]
    c. Partnership [ ]
3. What type of construction activities are you engaged in?
    a. Estate development [ ]
    b. Factories [ ]
    c. Educational buildings [ ]
    d. Commercial buildings [ ]
    e. Hospitals and clinics [ ]

4. What percentage of project expenditure is spent on formwork for temporary works?
    a. 0 – 10 % [ ]
    b. 11 – 20 % [ ]
    c. 21 – 30 % [ ]
    d. Over 30 % [ ]

5. Do you have a wood (carpentry) department?
    a. Yes [ ]
    b. No [ ]

6. How skilled are personnel?
    a. Skilled [ ]

Appendix A (iii)

b. Semi-skilled [ ]

c. Unskilled [ ]

d. All the above [ ]

7. Who does the purchasing of timber?

a. Head of the woodworking department [ ]

b. Purchasing officer [ ]

c. Others (specify)…….

8. Where do you obtain your timber?

a. From the mills [ ]

b. From the market [ ]

c. Other (please specify) ……

9. What method of seasoning is used?

a. Natural [ ]

b. Artificial [ ]

c. No seasoning is required [ ]

10. Is the seasoning done as required / necessary?

a. Yes [ ]

b. No [ ]

11. Is the timber well treated and preserved?

a. Yes [ ]

b. No [ ]

c. No treatment and preservation [ ]

12. How do you store timber meant for formwork before and after usage?

a. Direct on the ground in an open area [ ]

b. On raised platform [ ]

c. Other (specify)……

13. What is the level of waste generated from timber formwork?

a. Low [ ]

b. Moderate [ ]

Appendix A (iv)

c. High [ ]

d. Very high [ ]

14. What is the main cause of waste generated from timber formwork?

a. Deliberate [ ]

b. Accidental [ ]

c. Normal causes [ ]

d. Others (specify) ……..……

15. What measures have you put in place to minimize wastage of timber used for formwork in your firm?

a. By education [ ]

b. By strict supervision [ ]

c. Adopting new materials [ ]

d. Other (specify) ……

STEEL FORMWORK

16. How long have you been using steel formwork?

a. 1 – 5 years [ ]

b. 6 – 10 years [ ]

c. 11 – 15 years [ ]

d. 16 – 20 years [ ]

e. More than 20 years [ ]

17. Which part of the building do you use metal formwork?

a. Foundations [ ]

b. Columns [ ]

c. Beams [ ]

d. Walls [ ]

e. Slabs [ ]

f. All the above [ ]

18. What percentage of project expenditure is spent on steel formwork in general?

a. 0 – 10 % [ ]

Appendix A (v)

b. 11 – 20 % [ ]

c. 21 – 30 % [ ]

d. Over 30% [ ]

19. How do you acquire the steel formwork?

a. Locally manufactured [ ]

b. Imported [ ]

c. Both locally and imported [ ]

20. Is iron ore mined and smelted in Ghana?

a. No [ ]

b. Yes [ ]

c. Do not know [ ]

21. What are the advantages of steel formwork over other materials like timber, panels (plywood) and aluminium in terms of cost?

……

22. How do you maintain the steel formwork?

.....

23. How do you transport and stack steel formwork on the site before and after use?

.....

24. What factors do you consider when choosing steel formwork?

.....

25. From the use of forms over the years, which types(s) of formwork offer(s) the most desire finishing and why?

.....

26. How would you compare steel formwork to timber formwork in terms of quality of work, labour, speed of erection and striking and strength?

.....

27. How would you compare steel formwork and timber formwork availability?

.....

Appendix A (vi)

28. What are the levels of reuse of steel formwork?

.....

29. Can steel formwork be recycled or reused for other purposes?

.....

30. Does it pose any threat to the environment through these processes?

.....

31. Is iron ore mined and processed in Ghana?

.....

32. How do you compare logging and iron ore mining creation of environmental degradation to plant, animals and indigenous people in mining areas?

.....

34. What advice would you give to the government on the use of timber and steel as far as sustainability of these materials are concerned?

……

……

APPENDIX B (i)

Plate 1. Clearing of Forest before Logging Operations Begins
Source: Green Carbon, Black Trade: Illegal Logging

Plate 2. Burning of Forest as Part of Forest Degradation.
Source: Green Carbon, Black Trade: Illegal Logging

Appendix B (ii)

Plate 3. Illegal Logging Operations
Source: Green Carbon, Black Trade: Illegal Logging

Plate 4. Poor Storage of Logs before Conversion
Source: Green Carbon, Black Trade: Illegal Logging

Appendix B (iii)

Plate 5. Total Destruction of the Forest due to Logging
Source: Green Carbon, Black Trade: Illegal Logging

Plate 6. Poorly Stacked Fresh Timber at a Site
Source: Kinbu Sec. Tech. School, Accra (New Class Room Block).

Appendix B (iv)

Plate 7.Timber Formwork for a Storey Building
Source: New Officer Block (Burma Camp), Accra.

Figure 8. Timber (Bamboo) Formwork for an Overhead Water Tank
Source: Burma Camp, Accra. China State Haulong

Appendix B (v)

Plate 9. Timber Formwork for Reinforced Concrete Culvert
Source: Giffard Road, Burma Camp, Accra. China State Haulong

Plate 10. Poor Concrete Finish of a Timber Formwork.
Source: Source: Giffard Road, Burma Camp, Accra. China State Haulong

Appendix B (vi)

Plate 11. Poor Stacking of Timber Removal.
Source: Kinbu Sec. Tech. School (New Class Room Block), Accra.

Plate 12.Storage of Circular Steel Formwork.
Source: Guangzhou Safety Scaffolding Co., Ltd., Tema.

Appendix B (vii)

Plate 13. Storage of Steel Formwork
Source: Guangzhou Safety Scaffolding Co., Ltd.

Plate 14. Erected Circular Column Steel Formwork
Source: Source: Giffard Road, Burma Camp, China State Haulong

Appendix B (viii)

Plate 15. Reinforced Concrete Circular Column after Striking
Source: Source: Giffard Road, Burma Camp, China State Haulong

Plate 16.Reinforced Concrete Structure after Using Steel Formwork
Source: Source: Giffard Road, Burma Camp, China State Haulong

Appendix B (ix)

Plate 17. Erection of Concrete Wall with Combination of Steel and Timber Formwork
Source: Source: Giffard Road, Burma Camp, China State Haulong