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A STUDY INTO THE STANDARD OF PRECAST SANDCRETE BLOCKS PRODUCED BY THE COMMERCIAL MANUFACTURERS IN SEKONDI/TAKORADI METROPOLIS

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DECLARATION

STUDENT'S DECLARATION

I, SELASSIE KOFI FIAHAGBE, declare that this Dissertation, with the exception of references 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 another degree elsewhere.

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SUPERVISOR'S DECLARATION

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

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DEDICATION

This Dissertation is dedicated to my late parents (Mr. and Mrs. Fiahagbe), wife (Mrs. Florence Abena Fiahagbe), children (Samuel, Peculiar and Selina), siblings, nephews and nieces.

To the staff of Directorate of Works and Physical Development and the entire Takoradi Technical University fraternity.

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ABSTRACT

Throughout Ghana and many parts of the world precast sandcrete blocks have been and is still widely used as the main building material for wall units. The quality and importance of the usage of precast sandcrete blocks for the construction of walls therefore cannot be underestimated. The aim of this study was to ascertain the standard and quality of precast sandcrete blocks produced by commercial manufacturers in the Sekondi-Takoradi Metropolis. In order to achieve the aim, the study sought to; assess the manufacturers' compliance with the required standard mixed ratio; assess the curing time of the sandcrete blocks. Experimental research approach was used to investigate the engineering properties of the machine vibrated precast sandcrete blocks. To achieve the research objective of assessing the compliance of the block manufacturers to standard mixed ratio and curing method, questionnaires were prepared and used to solicit information from the block manufacturers. In total ninety (90) units of the machine-vibrated precast sandcrete blocks was selected from thirty (30) manufacturers in the Skekondi-Takoradi Metropolis. Three blocks samples of size 450mm × 150mm × 225mm was selected from each of the thirty (30) manufacturers which was subjected to compressive strength test. The study concluded that Ghana Standard Authority who has to set standard for the production of blocks do not take samples of blocks from the manufacturers to test in the Sekondi-Takoradi Metropolis, crushing strength of the various precast sandcrete blocks samples tested falls far below the recommended standards in the Secondi-Takoradi Metropolis and Majority of the commercial block manufacturers operating within the Sekondi-Takoradi metropolis produce precast sandcrete blocks using either the 1:6 cement to sand ratio or better. The study recommends Ghana Standard Authority should be going in for samples of blocks from the manufacturers to test in order to ensure standardisation, clients/contractors to seek expert advice before they buy their blocks from recommended manufacturers for their projects and silt test should be conducted on the sand before it's used for the manufacturing of the blocks.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Along with food and clothing, the provision of shelter a basic need to sustain the lives of human beings on the planet Earth. This is because having shelter protects one from the harsh conditions of the weather. A report from the Ghana Statistical Service indicated the number of houses in Ghana between the year 2000 and 2010 had been increasing by 4.4 percent annually (GSS, 2014). Conversely, the same report reported that, averagely, two households (which have an average of 7 members each) occupy a building. This is a clear indication that there is a huge housing deficit within the country as a result of the growing population. Owing to this, majority of Ghanaians living in both the rural and urban areas have resorted to constructing buildings either for commercial purposes or their personal use. However, it costs a lot to construct a decent accommodation and so house owners, in collaboration with building professionals, have been devising means of cutting down cost by compromising on quality standards or using substandard raw materials which can be detrimental to society in the long run.

As a result of the huge cost involved in constructing buildings, builders try to use building materials (such as wood and precast sandcrete blocks) that would reduce their overall cost. The precast sandcrete blocks which are the most common and widely used material for constructing the walls or wall units of buildings in most parts of the world, particularly in West Africa and Asia, are also sometimes produced in a manner that would minimize cost (Oyekan & Kamiyo, 2011). According to Sholanke, Fagbenle, Aderonmu and Ajagbe (2015), precast sandcrete blocks are made up of natural sand, water and cement as binder. These components of precast blocks are mixed accordance with standard ratio to ensure their good quality. However, this and other standards have been observed to be hardly adhered to. As a result the building that has been constructed to standard a test of time becomes defective with cracks and, at worse, collapse – though a building's lifespan can be shortened through natural occurrences such as earthquakes, floods, typhoons, tsunamis, cyclones, etc..

In recent times, the collapse of buildings in the country has been on the upsurge. The city of Accra – capital city of Ghana alone, officially recorded four major building collapse that resulted in the death of 19 innocent people between 2012 and 2014 (Bediako, 2015). When these happened, innocent people lost their lives while others were rendered permanently disabled. The collapse of the Melcom building near Achimota in 2012 alone claimed 14 lives. Also, in the event of such collapses, properties worth millions of Ghana cedis were destroyed whiles the entire nation is plunged into incurring huge costs through the clearing of debris and rescue of survivors.

Buildings are supposed to save the lives of people from the harsh conditions of the weather. However, there has been the rise of buildings, both for commercial and private purposes, collapsing in the country in recent years. In 2012, the Melcom building near Achimota (a suburb of Accra) collapsed in a tragedy while shoppers were busily shopping, claiming 14 lives in the process (Bediako, 2015). Aside the loss of innocent lives through such accidents, several people became permanently disabled as properties worth millions of Ghana cedis were destroyed as a result of such incidents. Moreover, the occurrence of such accidents plunges the property owners and the entire nation into incurring huge costs to clear the resulting debris and to rescue survivors.

Though it is not beyond reasoning for buildings to collapse, the alarming rate at which buildings have been collapsing in the country recently is a cause for citizens, particularly those in the construction profession – in line with their competencies, to worry. It is a fact that a building's lifespan can be shortened through either natural disasters such as earthquakes, floods, tsunamis, etc. or man's negligence such as lack of investigation into the soil type in which the building would be situated; poor building planning and design; use of sub-standard building materials such as blocks, cement, iron rods, etc.; engaging incompetent contractors; and lack of enforcement of building standards and codes (Bediako, 2015). Fortunately, Ghana has been blessed out of experiencing such natural disasters and so there is indication that virtually every structural failure in the country could be traced to negligence in our construction industry.

As one of the main materials used in the construction of buildings in most part of Africa, precast sandcrete blocks used to be manufactured by the owners or users themselves. However, due to lack of time and cost for producing precast sandcrete blocks by oneself coupled with the demand to meet deadlines for completing and submitting projects, many turn to commercial precast sandcrete block manufacturers for their rescue. This has caused an increase in the number of commercial manufacturers whose sole objective is to minimize cost in order to maximize their profits and as such tend to produce precast sandcrete blocks that do not meet the required industry standard through the use of either substandard materials or compromise of standards. Thus, the precast sandcrete blocks from such processes tend to lack in quality, making them risky to be used in constructing buildings.

As everything on earth has a lifespan attached to it, it is not beyond reasoning for buildings, either in Ghana or elsewhere, to collapse. However, considering the alarming rate with which buildings have been collapsing recently, there is a cause for every well-meaning citizen, particularly those in the construction profession, to worry. In view of this, this study is being conducted by the researcher who is a concerned construction professional to ascertain the quality standards of commercially produced precast sandcrete blocks.

1.2 Statement of the Problem

Building is an artefact that is designed to serve as dwelling place, for number of decades or years. But at times some deteriorate within the shortest possible time due to application of the materials (Miura, 2002) the components that make up a building are the roof, columns, beams and lintels, blocks, screed, concrete floor, doors and windows and their frames, louver frame and blade, reinforcement bars, finishes, ironmongeries, plumbing installations, electrical installation, etc. and they are the common building components that deteriorate most.

Seeley (1995), said that buildings have to meet the performance standard, prescribed by the Building Regulation 191; for instance the strength and stability of the building. The building should anticipate the early maintenance and running cost of the building that may occur at the design stage. He emphasized that the early defects in the fabric of the building may occur due to the variety of unrelated design decisions such as unsuitable materials, incorrect assessment of load and exposure.

To meet this performance, the standard and quality of precast sandcrete blocks which are used in conjunction with other component that form the framework of the building need to be improved upon.

As one of the main materials used in the construction of buildings in most part of Africa, precast sandcrete blocks used to be manufactured by the owners or users themselves. However, due to lack of time and cost for producing precast sandcrete blocks by oneself coupled with the demand to meet deadlines for completing and submitting projects, many turn to commercial precast sandcrete block manufacturers for their rescue. This has caused an increase in the number of commercial manufacturers whose sole objective is to minimize cost in order to maximize their profits and as such tend to produce precast sandcrete blocks that do not meet the required industry standard through the use of either substandard materials or compromise of standards. Thus, the precast sandcrete blocks from such processes tend to lack in quality, making them risky to be used in constructing buildings.

Precast sandcrete blocks that are prepared by the commercial manufacturers are of a doubt whether the right standard or quality and strength needed of a block are produced, since most of these manufacturers alter the required cement, fine aggregate (sand) and water cement ratio mix of the precast sandcrete blocks.

In view of this, many studies have been conducted in Nigeria to ascertain the quality of the sandcrete blocks produced by commercial manufacturers for building construction (Oyekan, 2011; Omopariola, 2014; Arimanwa, Arimanwa, Okere & Awodiji, 2014 and Awolusi, Soyingbe & Oyeyipo, 2015). However, very few studies have been conducted in Ghana to look into the quality of the sandcrete blocks manufactured by commercial manufacturers (Baiden & Tuuli, 2004 and Danso, 2005). Hence, this study therefore seeks to bring to light the quality of precast sandcrete blocks produced in the Sekondi-Takoradi Metropolis, which will serve as a reliable source of data and contribute significantly to literature on precast sandcrete blocks which policy makers and the regulators (Ghana Standard Authority) can use as a basis for policy action.

1.3 Aim and Objectives of the Study

1.3.1 *Aim of the Study*

The purpose of this study is to ascertain the standard and quality of precast sandcrete blocks produced by the commercial manufacturers in the Sekondi-Takoradi Metropolis.

1.3.2 *Objective of the Study*

In achieving the aim of the study, the study sought to:

i. Assess manufacturers' compliance with the required standard mixed ratio.

ii. Assess the curing time of the sandcrete blocks from the commercial manufacturers.

iii. Examine the engineering properties (compressive strength, water absorption and density) of the blocks from the commercial manufacturers.

1.4 Research Questions

The following questions were formulated to achieve the objectives for the study:

i. What are the sand, cement and water mix ratios of precast sandcrete blocks from commercial manufacturers, are they the same as the required standard?

ii. How does commercial manufacturers cure blocks within the standard range of days required?

iii. Are the standards of the compressive strength, compaction, water absorption and density of the blocks from the commercial manufacturers the same as the required standard?

1.5 Significance of the Study

Since the study sought to assess the quality standards of the precast sandcrete blocks manufactured commercially, the outcome of the study would inform stakeholders such as Ghana Standard Authority, Environmental Protection Agency and Ghana Institute of Engineers of the substandard products that are being produced for consumers. This would also help such bodies take the necessary actions to ensure that the required standards are met as well as put commercial block manufacturers on their toes to comply with the required standards.

The outcome of the study would also add to the body of knowledge on the quality standard of precast sandcrete blocks produced by commercial manufacturers. This is due to the fact that the outcome of the study would serve as a reference material for related research and as a basis for further research in the area of study in the near future.

1.6 Limitations of the Study

The study could have been conducted to include more of the block making factories within the boundaries of Sekondi-Takoradi Metropolitan Assembly as well as more of the engineering tests such as compressive strength, compaction, water absorption and density. However, due to the fact that it was conducted alongside active academic work as well as responsibilities from the office, there was insufficient time to conduct an extensive study on most of the block making factories within the Sekondi-Takoradi Metropolis. Each of the various engineering tests that were carried out at the laboratory was quite expensive. Thus, only a few of the engineering tests was conducted since the study was solely funded by the researcher.

Moreover, as a result of lack funds only a few respondents were selected for the study though more of the commercial manufacturers could have been included in the study, indicating that more funds would have been required to print out more questionnaires. There was lack of cooperation from the commercial manufacturers of precast sandcrete blocks and as such there was a little difficulty in retrieving the questionnaires that were given to them.

1.7 Scope of the Study

Ideally, the study could have been conducted to cover beyond the boundaries of the Sekondi-Takoradi metropolis. That is, the study could have been conducted on all the commercial manufacturers of precast sandcrete blocks operating within Western region. However, due to constraints such as time and funds the study was only conducted on precast sandcrete block manufacturers operating within the jurisdiction of the Sekondi-Takoradi Metropolitan Assembly (STMA). Furthermore, the study was limited to only ten (10) commercial precast sandcrete block manufacturers spread within the STMA. The respondents for the study were made up of both the managements and operatives of the selected precast sandcrete block manufacturers.

1.8 Layout of the Report

The report of the study is structured in five chapters. Chapter one introduced the study through headings such as the background, statement of the problem, aim and objectives, and significance of the study. It also comprised the scope of the study and structure of the study's report. The chapter two dealt with a review of relevant literature from previous works on the quality of sandcrete blocks. The kind of tools and methods employed to achieve the set objectives were discussed under Chapter three. The methodology employed for the study include the research design, sampling, data collection instrument and data collection method as well as the method of analysis used to analyze the data. Chapter four looked at the presentation of the data analysis as well as the discussion of the obtained results. The summary, conclusion and recommendations emanating from the study were dealt with in Chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter deals with reviewing the literary works of other researchers on the topic. The chapter consists of an overview of precast sandcrete blocks and the qualities of constituents of precast sandcrete blocks. In view of this, the study looked at the standards qualities of fine aggregate (sand), cement and water as well as the curing strength of the precast sandcrete blocks. The chapter also looks at the engineering properties of the precast sandcrete blocks which includes the compressive strength, compaction, water absorption and density of the blocks.

2.1 Overview of Sandcrete Blocks

2.1.1 *History of Sandcrete Blocks*

Concrete has been used as part of the materials for construction since the days of old – dating as far back to the reigns of ancient Egypt and Roman Empires to forge civilization in the development of infrastructure, industry and housing (Beiter, 1900). The oldest house which was made of concrete blocks existed in the United States of America and was built with natural cement concrete in New York (specifically, on Staten Island) in 1837 (Hall, 2009). It has since become one of the major materials for the construction industry. As the most common material used in construction works, concrete represents more than sixty percent (60%) of the materials used in constructing infrastructures all around the world (Concrete NZ, 2011). Thus, it is without doubt that the construction industry would not be able to meet the modern and, excessively, demanding lifestyles of today's world without concrete.

According to Emmitt (2005), the concrete blocks that are commonly used all around the world today were invented around the middle of the 1800s and were initially made in the ancient societies as sunbaked clay bricks (humanity's oldest manufactured product). Due to their durability and ability to withstand earthquakes, fires and time as testified by the existence of ancient structures such as the Egyptian Pyramids, Roman Coliseum and The Great Wall of China, bricks and concrete blocks have been used for construction as well as been the spine of civilization for a very long time. In relation to this, Stephens (2015) further indicated that sunbaked clay bricks have been used for construction for over 6,000 years.

At the initial stage of brickmaking, sunbaked bricks were essentially made of clay. However, ancient masons mixed the clay with either straws or grass to enable the blocks to maintain their rectangular shape and fired in kilns to improve their durability (Beiter, 1900). These bricks were used for various construction works until the discovery of concrete which in turn replaced them, though some parts of the world, especially the developing countries, continue to use them to construct durable affordable low-cost housing (Stephens, 2015). Concrete as the modern world knows it was first made in wooden frames in the early 1800s. Initially the material was dried and laid like brick with mortar. The first precast concrete blocks were cast in wooden frames, dried like bricks into a solid form, and then laid in mortar like bricks, as well. Many individual contractors were creating these precast blocks by the mid-1800s (Gulf Cement Industries, 2013). The inventor credited with the modern formula of concrete is an Englishman named Joseph Aspidin. He called it Portland cement after a type of stone native to the Isle of Portland. Joseph Monier invented reinforced concrete, which uses embedded metal, in 1849 and received a patent in 1867. Following these events, concrete began to replace other building materials for personal and commercial properties.

The cost of Portland cement fell as newly invented machines filled factories and shortened the manufacturing process. Builders responded to the pressure of building fire and weatherproof housing for investors and homeowners. Concrete blocks accomplished that goal and became the material of choice for many builders. Concrete structures are still very common especially for commercial and government buildings. These days even cheaper materials like dry wall are used for housing developments, but the foundations are still predominately concrete blocks and brick. Some theorists are now speculating whether the ancient Egyptians invented concrete, but while this is interesting, sufficient evidence has not been produced (Gulf Cement Industries, 2013). But the concrete block was not invented until the 1830s. Widespread manufacture of concrete blocks began in the early 1900s, and their popularity grew rapidly. Since then, they have been used in an enormous number of projects including basement walls, commercial buildings and more. In 1824, an English inventor named Joseph Aspidin invented a style of cement, a modified form of which is still the dominant type in construction today. It was made of powdered limestone and clay mixed with water. Aspidin named Portland cement after a type of building stone that was quarried on the Isle of Portland in Dorset, England. In 1868, the Frear Stone Manufacturing Co. of Chicago began manufacturing G. A. Frear's patented concrete blocks with decorative trim, less expensive than carved stone (Gulf Cement Industries, 2013). This was the first commercial manufacture of concrete block, and many of these blocks survived the 1871 Chicago fire. Improvements to Portland cement and its falling cost, along with a newly invented machine, revolutionized the concrete industry in the early 1900s. This cast-iron machine constructed hollow concrete blocks and made widespread production possible. Harmon Palmer obtained his patent in 1900, and within 10 years, over a thousand companies and individual contractors were making hollow concrete block (Gulf Cement Industries, 2013).

The introduction of the first concrete block, or concrete masonry unit, in 1882 led to a different technique that could be used for building. In 1900, Harmon S. Palmer patented the first commercial machine that could be used to create concrete masonry units, CMUs. The concrete blocks that Harmon's machine produced were composed of Portland cement, aggregates, and water and were 30"x8"x10". Since the blocks were so large, they had to be set in place by a hand cranked machine. However, with the scarcity of other resources and the cost of materials at the time, concrete blocks became the main source of building materials and the industry grew rapidly. The creation of the commercial process for manufacturing concrete blocks has led to the employment of concrete blocks for many different architectural and engineering functions since CMUs can last long periods of time, are energy efficient, require minimal upkeep and are fire and rot resistant (Beiter, 1900).

2.1.2 *Definition of Sandcrete Blocks*

According to Chudley and Greeno (1998), blocks are walling units exceeding in length, width or height the dimensions specified for bricks in BS 3921. Precast concrete blocks should comply with the recommendations set in BS 6073. GS 297:2003 states that block is a masonry unit which when used in its normal aspect exceeds the length or width or height specified for bricks and of size and weight such as to allow it to be handled readily by one man. Emmitt and Gorse (2005) also states that building blocks are wall units, larger in size than a brick which can be handled by one person. Building blocks are made of concrete or clay.

2.2 Dimensions of Blocks

The concrete blocks that Harmon's machine produced were composed of Portland cement, aggregates, and water and were 30"x8"x10". Since the blocks were so large, they had to be set in place by a hand cranked machine. However, with the scarcity of other resources and the cost of materials at the time, concrete blocks became the main source of building materials and the industry grew rapidly (Beiter, 1900).

The dimensions of the block shall be as specified below:

Table 1A: Dimension of Blocks

Nominal Size – mm		
Length	Height	Thickness
400	100 200	75, 90, 100, 140, 190, 220

Source: GS 297, 2003

Corresponding actual size shall as follows

Table 1B: Dimension of Blocks

Actual Size – mm		
Length	Height	Thickness
390	90 190	75, 90, 100, 140, 190, 220

Source: GS 297, 2003

Sizes of sandcrete blocks other than those specified in Table 1A and 1B were also used by mutual agreement between the purchaser and the supplier (GS 297, 2003).

According to Nash (1983), states that precast sandcrete blocks specified as Type A of Table 2, that are those having a block density of not less than 1500kg/m^3.

Their sizes are listed in the Table below

Table 2. Block Sizes

Type of block	Length by Height (co-ordinating size) (mm)	Thickness (work size) (mm)
	400 by 100	75, 90, 100, 140, 190
	400 by 200	140, 190
A	450 by 225	75, 90, 100, 140, 190, 225
	400 by 100	75, 90, 140, 190
	400 by 200	
	450 by 200	
B	450 by 225	
	450 by 300	75, 90, 100, 140, 215
	600 by 200	
	600 by 225	

Source: Nash, 1983

As indicated in Table 2, an allowance of 10mm is included in all the coordinating sizes for the vertical and horizontal joints; thus the 'work size' of 400 by 100mm block would be 390 by 90mm and so on. (Nash, 1983).

2.3 Types of Precast Sandcrete Blocks

According to Emmit and Gorse (2005) these are used extensively for both load bearing and non-load bearing walls. A concrete wall can be laid in less led time and may cost up of half as much as a similar brick wall. Lightweight aggregate concrete blocks have good insulating properties against transfer of heat and are used for inner leaf of cavity walls concrete may be used as a fairface external wall finish. The blocks are accurately moulded to uniform sizes from aggregate of natural stones with plain or rugged exposed aggregate finish are also available. Concrete blocks are manufacture from cement and either dense or lightweight aggregate as solid, cellular or hallow blocks.

2.3.1 *Cellular Block*

As shown in Plate 1, a cellular block has one or more holes or cavities that do not pass wholly through the block. It should have one or more voids which do not pass right through the block. A block shall be deemed to be cellular if it has one or more moulded holes or cavities which do not effectively pass through the block and the solid material is 50% and 75% of the total volume of the block calculated from the overall dimensions.

Plate 1: Typical Details of Cellular Block

2.3.2 *Hollow Block*

A hollow block is one in which the holes pass through the block as shown on Plate 2.

The thicker blocks are made with cavities or holes to reduce weight and drying shrinkage. It must have one or more voids which pass through the block. A block shall be deemed to be hollow if it has one or more large holes or cavities which pass through the block and the solid material is between 50% and 70% of the total volume of the block calculated from the overall dimensions.

Plate 2: Typical Details of Hollow Block

2.3.3 *Solid Block*

Solid block have no formed voids as shown in Plate 3.

Solid Block: A block shall be deemed to be solid if the solid material is not less than 75% of the total volume of the block calculated from the overall dimensions.

Plate 3: Typical Details of Solid Block

The most commonly used size of both dense and lightweight concrete blocks is 440mm long by 215mm high. The height of the block is chosen to coincide with three courses of brick for the convenience of building in wall ties and also bonding to brickwork. The length of the blocks is chosen for laying in stretcher bond. For the leaves of a cavity wall internal load bearing walls 100mm thick blocks are used .for load bearing partition walls 60 or 75mm thick lightweight aggregate blocks are used. Either 440mm by 215mm or 390mm by 190mm blocks may be used (Emmit & Gorse, 2005).

2.4 Classification of Blocks

Requirements for solid or hollow concrete blocks are designated into Class A, B or C according to their properties. These are normally intended for use as follows:-

Class A – for external use; load bearing or non-load bearing.

Class B – for external use; load bearing or for external use; load or non-load bearing if protected by rendering or effective manner.

Class C – for external use; non-load bearing (GS 297, 2003).

2.5 Compressive Strength

It is commonly known that concrete becomes very hard and can withstand enormous pressures; a property which is called compression strength.

This compression strength depends mainly on the properties and quality of the cement paste and the aggregate

- If the aggregate consists of a soft or weak material, the concrete will be weak also
- If the aggregate is so dirty that there is no direct contact between the surface of the particles and the cement paste, the concrete will again be weak.

According to Emmitt and Goarse (2005), concrete blocks may be specified by their minimum average compressive strength for:

- All blocks not less than 75mm thick and
- A maximum average transverse strength for blocks less than 75mm thick, which are used for non-load bearing partitions.

According to GS 297 (2003), the average compressive strength of blocks shall not be less than the appropriate value given as is shown in Table 3. In addition, the compressive of each of the blocks so tested shall not be less than the value tabulated for an individual unit.

Table 3: Compressive Strength

Block Classification	Compressive Strength	
	Average of 8 blocks N/mm^2	Individual Unit N/mm^2
A	7.0	5.6
B	5.0	4.2
C	3.2	2.5

Note: - 1000lbf/in^2 = 7.0 N/mm^2

Source: GS 297, 2003

According to Nash (1983), precast sandcrete clocks must also have a resistance to crushing (expressed in newtons per square millimeter of gross horizontal area) of not less than 2.8N/mm^2, if the blocks are to be used for the construction of a wall of a residential building having one or two-storeys, and the height of each storey does not exceed 2.7m. In all other circumstances the blocks shall have a resistance to crushing of not less than 7N/mm^2.

2.6 Density

2.6.1 *Density of a Precast Sandcrete Block*

The resulting blocks will of course vary in weight according to the density of the aggregate used in their manufacture, but if they are made too large they may prove to be too heavy for one man to handle comfortably. Therefore if large unit are required then it will be necessary for them to be made hollow. If the hollow block is to be regarded as equivalent to a solid unit then the building regulation states that it must have an aggregate volume of not less than 50 per cent of the total volume of the block calculated from its overall dimension (Nash, 1983).

According to Woodside House, Winkfield, Windsor and Berks, typically the nominal densities of blocks range between 475 and 2200kg/m^3. The least dense and usually lightest being antoclaved aerated blocks and the densest and usually heaviest, being solid dense natural aggregate blocks. There is a wide range of densities and weights. The density of a block may be calculated by dividing the mass/weight of the block by the overall volume including holes and cavities.

2.7 Material Components

2.7.1 *History of Cement*

According to Seeley (1995), some sort of binding substance has been used since ancient times to hold together the stones, bricks etc. used in building. The earliest building cement was probably clay or ordinary mud. The Romans were master builders in brick and stone, and a large part of their success was because of their discovery of cement that was made by mixing a volcanic ash with burned lime. The Romans also made pure lime mortars and gypsum plasters. These materials were the only building cements until modem times.

The modern era of building cements began about 1760, when an English engineer discovered the most suitable composition for hydraulic cements. These are cements which will harden even under water. A few years later, in 1824, another Englishman invented Portland cement. He named it because of its similarity in appearance to a natural stone from Portland in England.

2.7.2 *Cements:*

According to Seeley (1995), cements are substances which bind together the particles of aggregates (usually sand and gravel) to form a mass of high compressive strength (concrete). The most commonly used cement is Portland cement which may be of the ordinary variety or be rapid-hardening. There are several other cements that will produce concretes with more specialised properties. The properties of concrete can also be modified by the addition of admixtures.

Portland cement: This is made by mixing together substances containing calcium carbonate, such as chalk or limestone, with substances containing silica and alumina, such as clay or shale, heating them to a clinker and grinding them to a powder. The basic requirements for Portland cement, as fully detailed in BS 12, cover composition, sampling procedures and tests for fineness, chemical composition, compressive strength, setting time and soundness. The cement combines with water to form hydrated calcium silicate and hydrated calcium aluminate. The initial set takes place in about 45 minutes and final set within ten hours, and develops strength sufficiently rapidly for most concrete work. The setting time of rapid-hardening cement is similar to that of ordinary Portland cement, but after setting it develops strength more rapidly, enabling formwork to be struck earlier. It also has advantages in cold weather (Seeley, 1995).

Low heat Portland cement: This type of cement is manufactured to comply with the requirements of BS 1370, and it sets, hardens and evolves heat more slowly than ordinary Portland cement. It is used primarily in large structures such as dams and massive bridge abutments and retaining walls which use large volumes of concrete, and where the generated heat cannot easily be dissipated and high early strength is not usually required (Seeley, 1995).

White and coloured Portland cements: White cement is produced by reducing the content of iron compounds in the cement through careful selection of the raw materials and using special manufacturing processes. Coloured cements are obtained by adding suitable pigments to white cement. These cements are mainly used for decorative purpose and have been introduced to good effect in floors and paving (Seeley, 1995).

Sulphate-resisting cement: This cement should comply with BS 4027. It is more resistant than ordinary Portland cement to the effect of sulphates, which are found in some soils (Seeley, 1995).

Hydrophobic Portland cement: This cement has been developed to prevent partial hydration of cement during storage in humid conditions, resulting in a reduction in early strength. Substances added during the grinding process form a water-repellent film around each grain of cement and so prevent deterioration during storage. During mixing the protective acid film is lost by abrasion and behaves as an air-entraining agent, but mixing time is normally about 25 per cent longer than for ordinary Portland cement (Seeley, 1995).

Portland blastfurnace cement: This is made by grinding a mixture of ordinary Portland cement clinker and granulated blastfurnace slag, complying with BS 4248. It prime advantage is the high resistance to chemical attack by sulfate-bearing waters and weak acods. It deteriorates rapidly if stored under damp conditions. Concrete based on this cement requires a longer mixing period and the surface of the finished concrete needs to be kept moist during curing (Seeley, 1995).

High alumina cement: This cement differs in method of manufacture, composition and properties from Portland cements and should comply with BS 915. Its main advantages stem from its very high early strength and resistance to chemical attack. Heat evolution is rapid, permitting the concrete to be placed at lower temperatures than ordinary Portland cement concrete. When mixed with a suitable aggregate, such as crushed firebrick, it makes an excellent refractory concrete to withstand high temperatures. It should not be used in structure concrete, which is accelerated by hot and damp conditions (Seeley, 1995).

Pozzolanic cements: These cements are mixtures of a Portland cement and a pozzolanic material (one combining with lime to form a hard mass). They offer good resistance to chemical attack, but the rate of heat evolution and strength attainment is reduced.

2.7.3 *Aggregates:*

According to Seeley (1995), aggregates are gravels, crushed stones and sand which are mixed with cement and water to make concrete. The two most essential characteristics for aggregates are durability and cleanliness; cleanliness includes freedom from organic impurities.

Fine Aggregate: This consists of natural sand, or crushed gravel or stone that is mainly passed through a 5mm British Standard sieve with a good proportion of the larger particles.

Coarse Aggregate: This is primarily natural gravel, or crushed gravel or stone that is mainly retained on a 5 mm British Standard sieve. Both types of aggregate should comply with the grading requirements of BS 882. Artificial coarse aggregates such as clinker and slag are used for light concrete. The maximum size of coarse aggregate is determined by the class of work. With reinforced concrete the aggregate must be able to pass readily between the reinforcement and it rarely exceeds 20 mm. for foundations and mass concrete work the size can be increased possibly up to 40 mm. the type of aggregate used directly influences the fire protection and thermal insulation qualities of the concrete (Seeley, 1995).

BRE Information Paper IP 16/89 describes how indigenous resources of porous carboniferous sand-stone in north-west England could make a significant contribution to the supply of aggregate for concrete for less demanding applications such as foundations and floor. However, there is a considerable variation in the quality of materials between different layers in some quarries, and they therefore require careful assessment to determine whether

1. Higher cement content may be required to achieve sufficient strength;
2. Drying shrinkage is too high for the proposed end use and exposure conditions;
3. Embedded metal may be needed to accommodate low elastic moduli of the concrete.

A BRE survey showed that some igneous rocks of the basalt and dolerite types and certain sedimentary rocks (especially greywacke and mudstone) can be shrinkable, and these are encountered extensively in the industrial belt of Scotland. Aggregate shrinkage produces increased shrinkage of concrete despite adopting good practice, although the shrinkage can be minimised by taking normal precautions, such as the careful control of mix proportions. As a general rule, the smaller the proportion of cement in the concrete or the larger the maximum particle size of aggregate, the less its shrinkage. However, even when such precautions are taken, the use of shrinkable aggregates may still have significant practical consequences for design (Seeley, 1995).

2.7.4 *Site Testing of Materials*

According to Seeley (1995), it is sometimes necessary to carry out site tests on materials to determine their suitability. The following tests relating to cement and sand serve to illustrate the approach.

Cement

1. Examine to determine whether it is free from lumps and is of a flour-like consistency (free from dampness and reasonably fresh).
2. Place hand in cement and if of blood heat then it is in satisfactory condition.
3. Settle with water as paste in a closed jar to see whether it will expand or contract (Nash, 1983).

Sand

1. Handle the sand; it should not stain hands excessively, ball readily or be deficient in coarse or fine particles.
2. Use a standard sieve test – if more than 20 per cent is retained on a 1.25 mm sieve, it is unsuitable for use.
3. Apply a silt or organic test – a jar half filled with sand and made up to the three-quarters mark with water; shake vigorously and leave for three hours; the amount of silt on top of the sand is then measured and this should not exceed six per cent (Seeley, 1995).

CHAPTER THREE

3.0 RESEARCH METHOD

The various methods that were employed by the researcher to conduct the study are discussed under this chapter. In view of this, the chapter is presented under headings such as the research design, population, sampling and sampling techniques, data collection instrument, data collection procedure and data analysis.

3.1 Research Design

As there are several kinds of researches, there are equivalent numbers of designs with which these researches are conducted.

Owing to the concept of research design, the study was conducted through the use of a combination of the descriptive and experimental research designs. Kothari (2004) added that using descriptive research design for conducting studies involves the collection of large amounts of data which describe the population of individuals, groups or situations and thus, lead to making practical significant recommendations. These indicate that the descriptive research design can offer researchers a knowledge base that can act as a springboard for other types of quantitative researches. On the other hand, Kothari (2004) held the opinion that the experimental research design allows the researcher to manipulate the persons or the materials concerned (the sample) so as to bring forth the desired information. In view of this, the experimental research design is characterized by the researcher's control over the variables under study and his or her deliberate manipulation of one of the variables to study its effects.

Descriptive and experimental designs were adopted to achieve the research objectives. Data from questionnaires administered to block manufacturers using purposive sampling to select the manufacturers, data was collated and analysed by descriptive analysis. Experimental study was undertaken on the blocks from the manufacturers to enable the determination of the percentage of silt content of the sandcrete block and their characteristic compressive strength.

3.2 Study Area

The study was conducted within Sekondi-Takoradi Metropolis; the twin city of Ghana and the regional capital of the Western Region. Administratively, Sekondi is the capital of the Sekondi-Takoradi Metropolis which occupies the south-eastern part of Western Region and shares boundaries with the Ahanta West Municipal and the Shama district. The study area is located on the West Coast of Ghana and it is about 200km west of Accra and 130km east of La Cote D'Ivoire. The Western Region has 13 districts, municipal and metropolis of which the Sekondi-Takoradi Metropolis is the most highly developed. The metropolis is an industrial and commercial centre with a population of 559,548 covering an area of 23,921km^{2}and is the fourth largest metropolis in Ghana (GSS, 2014). However, the folks in the rural areas of the metropolis are predominantly engaged in fishing and farming as their occupations.

The metropolis which is now referred to as "the oil city" has become highly cosmopolitan as a result of fact that the recent oil find in the country in 2007 has caused an influx of both foreign and domestic workers from various places into the metropolis (Planitz & Kuzu, 2015). Despite the creation of more jobs, Planitz and Kuzu (2015) added that the oil activities within the metropolis has caused it to be faced with high unemployment rate; increase in social vices such as prostitution, drug abuse, crime; increase in inflation and prices of products and services such as food, leisure and accommodation, as well as increased health implications from excessive pollution.

3.3 Population

There is always a group of people, animals, products or services upon which investigations are made. According to Dorofeev and Grant (2006), the group of people or objects that meets a set of criteria of researchers' interests to which researchers wish to generalize the findings of their studies by using a sample is what is considered as the population or the target population. In view of this, the target population for the study will consist of all the block-making factories in the metropolis. According to the Block

Manufacturers Association, there are fifty (50) registered block manufacturers in the metropolis.

3.4 Sampling and Sampling Techniques

A sample for a study is the portion of the population that is selected for investigation to help draw conclusions to be generalized to the population (Ofori & Dampson, 2011). According to Saunders, Lewis and Thornhill (2009), samples for studies are selected based on factors such as (a) the confidence level (i.e., the level of certainty that the characteristics of the data collected represent those of the total population); (b) the margin of error that can be tolerated (i.e., the accuracy required for any estimates made from the sample); (c) the types of analyses you are going to undertake: and (d) the size of the total population from which sample is being drawn. Purposive sampling was used to select the block manufacturers for the study. This technique was adopted because according to the Block Manufacturers Association in the metropolis, out of the fifty (50) registered manufacturers, only thirty (30) were in active business. The researcher therefore decided to use all the active members whose products were well patronised by clients.

3.5 Data Collection Instruments

The data for the study were obtained through laboratory measurements and self-administered questionnaires. The survey questionnaire for the study comprised three (3) sections: Sections A, B and C. The section A of the questionnaire was made up of two (2) close-ended questions soliciting information on the demographic characteristics of the businesses and the respondents whilst the section B solicited information on what went into the manufacturing of the blocks. The section B of the questionnaire was made up of six (6) close-ended questions with three (3) of them being multiple response questions – that is, questions which gives their respondents the freedom to select more than one appropriate responses or answers to them.

Section C, on other hand, was made up of five (5) questions soliciting information on how the commercial block factories within the Sekondi-Takoradi metropolis ensure that the blocks they manufacture are of good quality. The questions under this section consisted of three (3) close-ended and two (2) open-ended questions.

Similarly, the observational guide for the study consisted of five (5) items of interest. With these, the study sought to solicit information on:

i. the quality of sand used
ii. the method of mixing the cement and sand
iii. the type of equipment use for moulding the blocks
iv. the method of compaction used, and
v. the method used in storing the blocks

In conducting the laboratory analyses on the blocks or the masonry units, the study used Gilson Test Sieves to determine the distribution of aggregate particles by size within the sample. The test sieves are made of various sizes of screen opening.

The Accro-Tech semi-automatic compression testing machine was also used to test for the compressive strength of the blocks. In describing the compressive strength testing machine, the Constructor (2017) indicated that the machine consist of two steel bearing blocks with one being rigidly positioned to hold the blocks in place and the other being movable and responsible for transmitting the load onto the blocks when they are applied.

Finally, like any other data collection technique, the use of the questionnaire is not without problems. There have been issues of low response rates and response biases identified with questionnaire surveys. As such, the researcher personally administered the questionnaires in order to obtain a high response rate.

3.6 Data Collection Procedure

In collecting the data for the study, an introductory letter was obtained from the head of the School of Graduate Studies (University of Education, Winneba) to enhance the introduction of the researcher to the respondents as well as to explain to them the purpose for which the study was being conducted. After gaining their permission through the letter, the respondents were given self-administered questionnaires to completion after a few technicalities had been explained to them. In order to improve the response rate, the researcher administered most of the questionnaires personally instead of handing them over to the respondents. However, those who insisted on filling the questionnaires themselves were allowed to do so within twenty (20) minutes whilst those who were not able to complete the questionnaires at a spot because of them being busy and so would want to do so at a later date were given a maximum of three (3) days to do so.

A pilot study of the questionnaire was conducted in October, 2017 using three (3) block-manufacturing factories from Adiembra, Effia-Kuma and Anaji to test the appropriateness of the questionnaire items and respondents understanding of the questions. Saunders, *et al.* (2009) opined that pilot studies are normally carried out for questionnaires to ensure that respondents had little problems, if any, in completing them and also to ensure the reliability and validity of the items on them. The actual study was conducted two months after the pilot study.

3.6.1 *Laboratory Tests Undertaken*

Silt Test

Silt test is a test conducted on sand to determine the percentage of silt, clay or other fines present in the sand as shown on Plate 4. This test was done according to GSA standards. A saline solution was prepared by adding 2.5 grams of fine salt to 250ml water. 50ml of the saline solution was poured into a transparent measuring cylinder. The sand for the test was poured into the measuring cylinder till the water level in the cylinder rises to 100ml. the cylinder was covered and shaken vigorously for 15 minutes, the process was repeated by adding another 50ml of saline solution. The remaining 50ml of saline solution was used to wash the inner perimeter of the cylinder. The cylinder with the sand was placed on a flat level surface and allowed to stand. The first reading was taken after three hours (3 hours). The cylinder with water and sand was left to stand for another 24 hours. The level of silt and sand was measured after the 24 hours elapsed. The percentage of the silt and sand was calculated using the formular below:

$$\%\ \text{content of clay and silt} = \frac{\text{volume of sand and silt}}{\text{volume of sand}} \times 100 \quad \text{.............equation 3.1}$$

Plate 4: Silt Test being conducted

Compressive Strength Test on Sandcrete Block

Crushing test was done to obtain the maximum amount of force a material can bear before fracturing. The compressive test was conducted on the samples which has been cured for 21 days. Each sample was placed in the Accro-Tech semi-automatic compression testing machine, the load was released and the maximum load at which the sample failed was observed and recorded. The process was repeated for all the other sandcrete blocks.

According to GS 297 (2003) standards, the compressive strength of the sandcrete block were calculated as follow:

$$\text{Stress} = \frac{\text{Peak load (N)}}{\text{Area (mm)}} \quad \ldots\ldots\ldots\ldots\text{equation 3.2}$$

Finally, to avoid plagiarism, some statements which were taken from other related works were paraphrased and properly acknowledged using the American Psychological Association (APA) style of citation and referencing, if quoted verbatim.

Plate 5: Crushing test being conducted on a sandcrete block to determine the compressive strength.

3.7 Data Analysis

The obtained data from the survey were screened and edited for writing errors and incomplete entries. In view of this, questionnaires which are not filled at all or have about 80% of their questions not responded to or answered were discarded from the data set to improve the quality of the data.

Furthermore, the numbers that were assigned to the responses under the closed ended questions were retained as codes for data entries. On the other hand, the responses from open-ended questions were grouped based on their meanings and coded to facilitate data entry. Thereafter, the data from the survey were then analysed based on the objectives of the study using descriptive statistical tools such as frequencies, percentages and averages through the help of the version 23 of the SPSS (Statistical Package for Service Solutions) computer software.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents the result of the analysis of the data obtained from the survey questionnaires as well as that obtained from the laboratory experimental processes.

4.1 Experimental Approach

4.1.1 *Silt Test*

There were different sand samples taken from the various precast sandcrete block manufacturing sites for this test. Specifically a sand samples was taken from the site of each of the manufacturers.

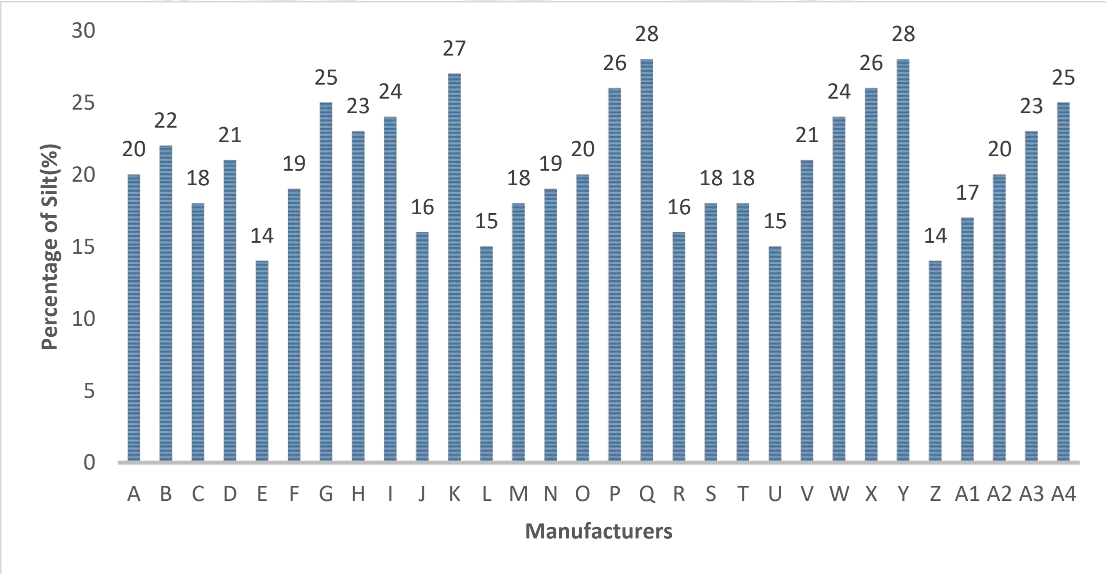

Figure 1: Average Percentage of Silt in Sand Used in Producing Blocks

It can be observed from Figure 1 that the average percentage of silt in the various types of sand used for moulding the precast sandcrete blocks varied between 14 and 28 percent. Figure 1 depicts that block manufacturers A, B, D, G, H, I, K, O, P, Q, V, W, X, Y, A2, A3 and A4 recorded average percentage of as high as 20% or more (20%, 22%, 21%, 25%, 23%, 24%, 27%, 20%, 26%, 28%, 21%, 24%, 26%, 28%, 20%. 23% and 25% respectively). It can also be observed from Figure 1 that rest of the block manufacturing companies use sands containing average silt content of between 14% and 19% to produce their concrete blocks. That is, companies C, E, F, J, L, M, N, R, S, T, U, Z and A1 recorded average percentage silt content of 18%, 14%, 19%, 16%, 15%, 18%, 19%, 16%, 18%, 18%, 15%, 14% and 17% respectively. These results indicate that the percentages of silt in the various types of sand used for manufacturing the precast sandcrete blocks were high and far above the recommended silt content which should not be more than 10% according to BS 882:1992. This implies that the companies are producing less quality blocks for the commercial precast sandcrete block market which agrees with Emmitt and Goarse (2005) who reported direct correlation between recommended quantities of contents of blocks and its quality.

4.2 Compressive Strength

Three precast sandcrete blocks were bought from each of the thirty (30) manufacturers to perform a crushing test on each of them to find their compressive strength and average compressive strength for the three blocks from each manufacture.

Table 4: Crush Test Result on solid blocks from different manufactures

Manufactures	Average Compressive Strength (N/mm²)
A	1.61
B	2.24
C	2.40
D	1.97
E	1.97
F	2.55
G	2.42
H	2.47
I	2.24
J	2.17
K	1.61
L	1.94
M	1.86
N	2.17
O	1.61
P	1.12
Q	2.73
R	1.90
S	2.15
T	2.67
U	3.09
V	1.87
W	2.93
X	2.95
Y	2.51
Z	2.84
A1	1.92
A2	2.47
A3	2.44
A4	1.51

It was observed from Table 4 that the average compressive strength of the three solid blocks from the manufactures varied between 1.12 and 3.09N/mm^2. Table 4 depicts that block manufactures A, D, E, K, L, M, O, P, R, V, A1 and A4 recorded a lower average compressive strength of 1.12 N/mm^2 to 1.97 N/mm^2 (1.61, 1.97, 1.97, 1.61, 1.94, 1.86, 1.61, 1.12, 1.90, 1.87, 1.92 and 1.51 N/mm^2 respectively). The following manufacturers B, C, F, G, H, I, J, N, Q, S, T, Y, A2 and A3 also compressive strength recorded a lower average compressive strength of 2.15 N/mm^2 to 2.73 N/mm^2 (2.24, 2.40, 2.55, 2.42, 2.47, 2.24, 2.17, 2.17, 2.73, 2.15, 2.67, 2.51, 2.47 and 2.44 N/mm^2 respectively) These results indicate that the average compressive strength of three blocks from each of the thirty blocks manufactures falls below the minimum compressive strength of 2.8N/mm^2 recommended by the Ghana Standard Authority (GS297, 2003). Out of the thirty manufacturers only four U, W, X and Z recorded a compressive strength of (3.09, 2.93, 2.95 and 2.84 N/mm^2 respectively), which is above the recommended compressive strength. This findings implies that most of the commercial sandcrete block manufacturers within the Sekondi-Takoradi Metropolis produces sandcrete blocks which does not meet the required standard set by the Ghana Standard Authority and in will affect the strength and life span of the structures they are used for.

4.3 Questionnaire

Data for the study was collected through questionnaire specially designed for this study. The questionnaire was used for data collection because:

- The questionnaire method facilitates the collection of a large amount of data;
- It provides a wider coverage of the sample than the interview method;

- It is economical in terms of effort since the questionnaire can be duplicated and distributed to many respondents to produce a large amount of data (Wallen & Fraenkel, 2001).

The development of the questionnaire was greatly influenced by information obtained from the literature reviewed at the early stages of the study to determine the extent of coverage of this area. The preliminary set of questions went through many drafts before it was put into a form for self-administration.

Questionaires were used in to solicit information from the the commercial blocks manufacturers on the types of blocks, material and processes used in the various manufacturing companies. The reponces are presented figures below.

4.3.1 *Types of Block Produced by Block Manaufacturers*

The questionars were used for data collection on the types of blocks produced by commecial block manufacturers and the results are presented in 2 below.

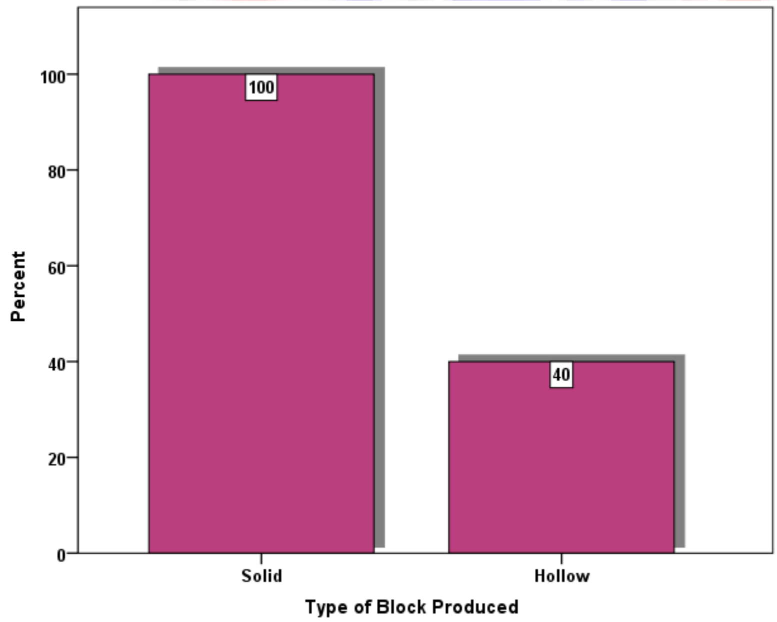

Figure 2: Types of Block Produced by Block Manufacturers

It can be observed from Figure 2 that though there are different types of blocks such as solid, hollow and cellular, the block manufacturing companies within the Sekondi-

Takoradi Metropolis generally produce solid and hollow blocks. Figure 2 shows that all of the sandcrete blockmaking companies produce solid blocks. It can also be seen that two out every five (40%) of the respondents indicated that their companies produce hollow blocks in addition to the production of solid ones. The findings agrees with Lekan (2013) who reported that, commercial sandrete block manufacturers largely produce solid blocks.

4.3.2 *Types of Cement Used by Manufacturers in Producing Blocks*

It was relized that the commercial block manufacturers uses cement in their production of precast sandcrete blocks. So the study find out the types of cement used in the manufacturing of blocks. The resulths are shown in figure 3 below.

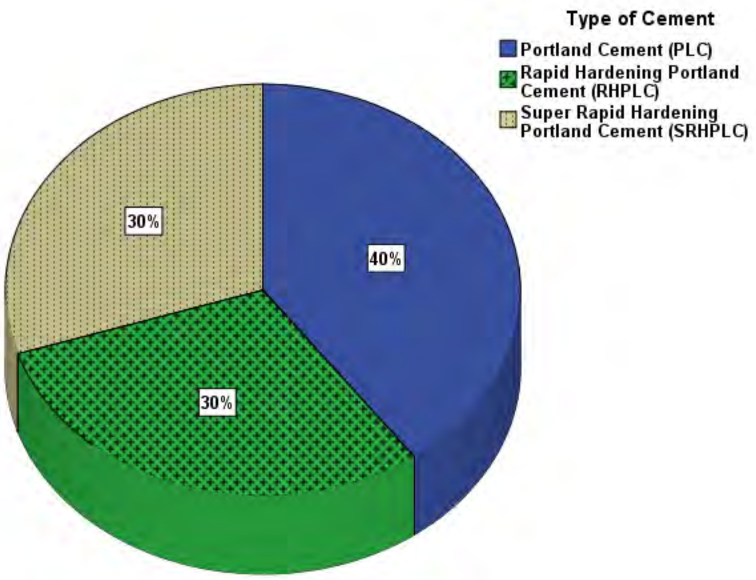

Figure 3: Types of Cement Used by Manufacturers in Producing Blocks

Figure 3 depicts that the precast sandcrete blocks made by commercial manufacturers within the metropolis are made from either the original Portland cement or an enhanced type. This is due to the fact that 40% of the respondents reported that their companies usually produce their precast sandcrete blocks by using Portland cement. About one-third of the respondents indicated that their outfits use Portland Cements with either rapid hardening (30%) or super rapid hardening (30%) characteristics. Though with varied enhancements, these results imply that Portland cement is the preferred choice of cement for precast sandcrete block manufacturing companies in the Sekondi-Takoradi metropolis, which was due to the proximity of the cement factory within the metropolis. This result agrees with Emmit and Gorse (2005) who stated that Portland land cement is used extensively because of is hardening properties and availability to construction firms.

4.3.3 *Types of Sand Used by Manufacturers in Producing Blocks*

The component materials for manufacturing varies as it is based on its properties. So the study find out the types of sand used in the manufacturing of blocks. The results are shown in figure 4 below.

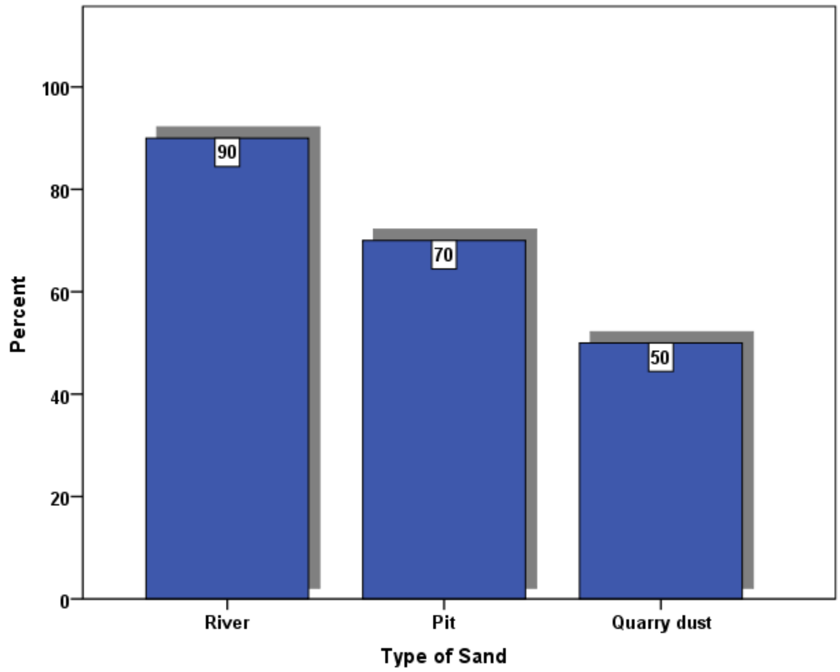

Figure 4: Types of Sand Used by Manufacturers in Producing Blocks

Though there are various types of sand such as those from rivers, pits and the sea as well as quarry stones, block manufacturing companies in the metropolis have been found to use river and pit sand as well as quarry dust as constituents in producing their precast sandcrete blocks. It can be observed that none of the commercial block factories used sand from the beach in producing its blocks whilst almost all (90%) of them reported that they have been using sand obtained got from rivers. Half of the respondents indicated that they use quarry dust as sand to produce their precast sandcrete blocks. Close to three-quarters of them (70%) indicated that they have been using pit sand as contituents in producing their blocks. This finding implies that most of the commercial sandcrete block manufacturers within the Sekondi-Takoradi metropolis have been using river and pit sands in their blockmaking more than their use of quarry dust which agrees with GSA (2013) assession that, blocks manufacturers margely use sand for producing blocks in Ghana.

4.3.4 *Types of Water Used by Manufacturers in Producing Blocks*

The study enquired on the kind of water used by commecial manufacturers for producing blocks. The results is illustrated in figure 5 below.

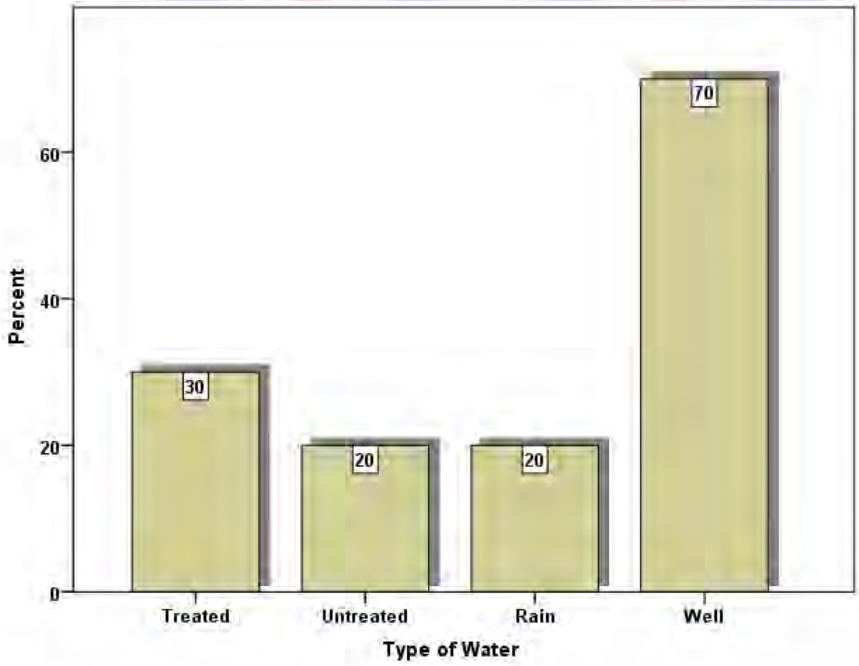

Figure 5: Types of Water Used by Manufacturers in Producing Sandcrete Blocks

Figure 5 shows that the commercial precast sandcrete blocks manufacturers have been using various kinds of water such as well water, rain water, untreated water as well as treated water to mix their mortars for their blocks. It can be observed from Figure 6 that 70% of the respondents indicated that they use well water to make their blocks. Surprisingly, 30% of the respondents reported that their companies use “treated water” to manufacter their blocks. One out of every five of the respondents reported that they either use “untreated water” (20%) or rain water (20%). The above findings indicate that most of the block manufacturing companies in the Sekondi-Takoradi metropolis have been using well water to mix their mortars for their precast sandcrete blocks. It was also realised that the compressive strength of the blocks manufactured by the companies that use treated water have higher compressive strength which goes to proved that treated water also help to have a quality block. This findings disagree with Aderonmu and Ajagbe (2015) assessment that, precast sandcrete blocks are made up of natural sand, water and cement as binder mixed in accordance with standard ratio to ensure their good quality

4.3.5 ***The ratio of cement and sand mix use***

Commercial precast sandcrete block manufacturers have been using various cement and sand mix ratios in their productions. Some of the common constituents’ mix ratios available include: 1:3, 1:4, 1:6, 1:8, 1:12 and 1:14. Figure 7 shows the result of the analysis on the cement and sand mix ratios that the precast sandcrete block manufacturing companies in the Sekondi-Takoradi metropolis employ

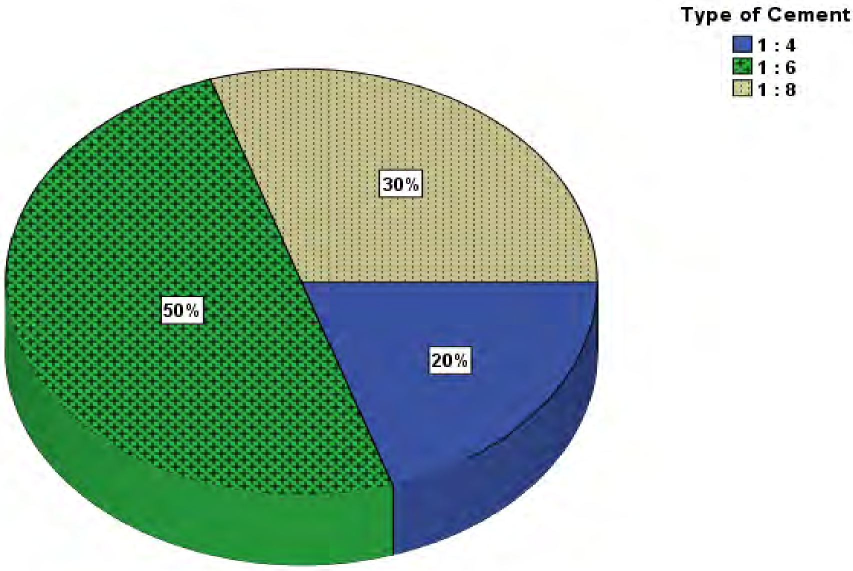

Figure 6: Types of Cement and Sand Mix Ratios Used in Producing Blocks

It can be observed from Figure 6 that half (50%) of the respondents indicated that they mix one (1) headpan of cement with six (6) headpans of sand to mould their precast sandcrete blocks. A little close to one-third (30%) of the respondents reported that they use more sand for their productions by employing the 1:8 ratio of cement to sand whilst, on the other hand, 20% of them reported that they produce cement-rich sandcrete blocks using the 1:4 cement to sand ratio mix. This finding indicates that majority of the commercial block manufacturers operating within the Sekondi-Takoradi metropolis produce precast sandcrete blocks using either the 1:6 cement to sand ratio or better. The findings agrees with Lekan (2013) 1:6 ratio of cement to sand in his study titled Sancrete block density and compressive strength relationships. But Beiter (1990) disagree with the ratios, who reported 1:3 cement to sand ratio better quality sandcrete blocks. This is a possible cost-effetive method of commercial sandcrete blocks manufacturers to maximise profit.

4.3.6 *Duration for Curing*

The period in days in relation to the percentage of curing sandcrete blocks were assessed and the results are presented in the chart below.

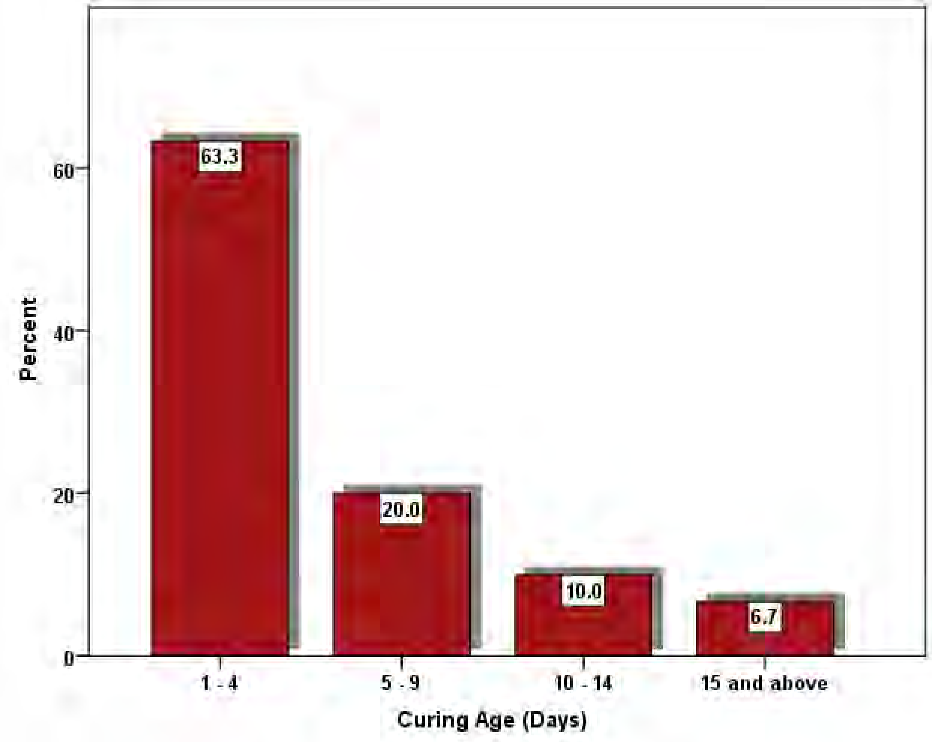

Figure 7: The Curing Age of Precast Sandcrete Blocks

It can be observed from Figure 7 that whilst about 63% of the respondents reported that they store the produced blocks for a maximum of 4 days before selling them out, a few (about 7%) of them reported that they keep the blocks for at least 15 days before they sell them to the public. Twenty percent (20%) of the respondents indicated that they keep the blocks for about a week before they are sold whilst 10% of them indicated that they do so for about 2 weeks before the blocks are sold. These indicate that most of the manufacturers in the metropolis cure their precast sandcrete blocks for a maximum of four (4) days and then sell them to their customers for use. This has a tendency affecting the quality as the time of curing have direct correlation with the quality of blocks produced as reported (GS 297, 2003)

4.3.7 *Does the Standard Authority often call in to Take Samples for Test*

Do officers from Ghana Standard Authority come and take samples for testing? The study investigated for empirical evidence of

Table 5: Visit of Ghana Standard Authority Officers to Worksites for Samples

Response	Frequency	Percent
Yes	12	40.0
No	18	60.0
Total	30	100.0

It can be observed from Table 5 that four out of every ten (40%) of the respondents reported that their companies have been receiving officers from Ghana Standard Authority at their sites to take samples of the manufactured precast sandcrete blocks for testing. On the other hand, most (60%) of the respondents reported that there has not been any form of visit by officers of Ghana Standard Authority to go for samples of precast sandcrete blocks for testing. This implies officers from Ghana Standard Authority do not often go to the worksites of the manufacturers of precast sandcrete blocks to take samples to examine. This collaborates with the report of low monitoring visits by the Ghana Standard Authority due to logistical challenges (GSA, 2013).

4.3.8 *Do you take samples to Ghana Standard Authority for testing?*

The study enquired from respondents whether they take samples to the Ghana Standard Authority for testing. The results are shown in the table 6 below.

Table 6: Taking of Samples to the Office of Ghana Standard Authority for Testing

Response	Frequency	Percent
Yes	11	36.67
No	19	63.33
Total	30	100.0

Table 6 shows that, virtually, all of the respondents (63.33%) stated that they have not been sending block samples to Ghana Standard Authority for examination or testing. Only (36.67%) of them reported that they have been taking samples of the sandcrete blocks to the office of Ghana Standard Authority for testing. This result indicates that the commercial sandcrete block manufacturers in the Sekondi-Takoradi metropolis mostly do not take samples of blocks to the office of Ghana Standard Authority to be tested. This implies that most of the blocks produced in the Secondi-Takoradi Metropolis are not satisfied Ghana Standard Authority products. This could be a similitude effect of low quality standards as reported by Bediako (2015) in the Melcom building collapsed in a tragedy while shoppers were busily shopping, claiming 14 lives in the process.

4.4 Results from Personal Observation and Interview Schedule

4.4.1 *Method of Mixing*

After the batching of cement and fine aggregate/sand, the materials were mixed together thoroughly manually before the required water was added and ready for moulding as shown in Plate 6. Most of the manufacturers stated that well water is what they use for the production of the precast sandcrete blocks, the well is dug at the site where the precast concrete blocks are produced. This is to eliminate the cost of paying of water bills which goes to reduce the cost per block, there are only a few who stated that they use treated water, rain water' and untreated water.

Plate 6: A mixture of cement and sand ready to be moulded into precast sandcrete blocks.

4.4.2 *Method of Moulding and Compaction*

All the manufacturers visited used mechanical means for the moulding and compaction of the precast sandcrete blocks as shown in Plate 7. The only time that some of them use the manual method is when power (electricity) is off and the precast sandcrete blocks are on high demand.

Plate 7: Power Machine being used to mould precast sandcrete block.

4.4.3 *Method of Storage/Stacking*

All the manufacturers stored/stacked the precast sandcrete blocks in the open air at the mercy of the weather after curing as shown in Plate 8, this in a way goes to affect the strength of the blocks if left in the open for a long time. This is a fall out of inadequate monitoring by the Ghana Standard Authority, so low standards are practiced by manufacturers.

Plate 8: Precast sandcrete blocks being cured after which it is packed and stored/stacked in the open air.

CHAPTER FIVE

5.0 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Findings

The experiment perform to check the percentage of silt content in both river and pit sand reveals that the quantity of silt in the various sand were too much. The percentages in the various sand ranges between 14% to 28%.

On the crushing test perform on the various precast sandcrete blocks samples, the results shows that the precast sandcrete blocks samples falls far below the recommended compressive strength required, since the compressive strength obtained ranges from 1.13 to 3.13 N/mm^2. The average compressive strength obtained from 3 precast sandcrete blocks from each manufacture ranges from 1.12 to 3.09 N/mm^2.

Most of the manufacturers used well water for the production of the precast sandcrete blocks. The manufacturers don't know the compressive strength of the blocks they produce. The duration for curing also differs from what is required/specified which in a way affect the strength of the block. The percentages of silt content in the various sand samples were too much. The crushing test carried out on the various precast sandcrete blocks samples shows that their crushing strength falls far below the required/recommended average crushing strength.

The findings from the questionaire administations shows block manufacturing companies within the Sekondi-Takoradi Metropolis generally produce solid and hollow types of blocks.The findings also indicates that, the precast sandcrete blocks made by commercial manufacturers within the metropolis are made from either the original Portland cement or an enhanced type.

5.2 Conclusion

In concluding, this study has revealed that,

i. Ghana Standard Authority who has to set standard for the production of blocks do not take samples of blocks from the manufacturers to test in the Secondi-Takoradi Metropolis.

ii. Crushing strength of the various precast sandcrete blocks samples tested falls far below the recommended standards in the Sekondi-Takoradi Metropolis.

iii. Majority of the commercial block manufacturers operating within the Sekondi-Takoradi metropolis produce precast sandcrete blocks using either the 1:6 cement to sand ratio or better.

5.3 Recommendations

Based on the research work the following recommendations were made.

a. That the Ghana Standard Authority who have set standard for the production of blocks should be going in for samples of blocks from the manufacturers to test if they are up to the standard they have set.

b. Since the crushing strength of the various precast sandcrete blocks samples falls far below the recommended standard, it will be advisable for clients/contractors to seek expert advice before they buy their blocks from recommended manufacturers for their projects. This will help to reduce the maintenance cost since the poor standard of the precast sandcrete blocks will develop cracks when they absorb water and shrinks.

c. That silt test should be conducted on the sand before it's used for the manufacturing of the blocks.

d. Ghana Standard Authority should set the required standard to be visiting the manufacturers and take samples for testing to make sure the required standard are met during production, in the same way clients/contractors should do likewise before they buy in bulk for their project.

e. Since the sand available contains too much silt it is advisable for the manufacturers to increase the quantity of cement in the cement and sand mixture, so instead of a ratio of 1:6 it should be 1:4 or 1:5.

5.4 Suggestions

Based on the aims, objectives and the importance of the research, I suggest that further studies could be carried out to determine the water absorption and moisture content and drying shrinkage of precast sandcrete blocks produced by the commercial manufacturers in Sekondi-Takoradi Metropolis.

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APPENDICES

Appendix A:

Crush Test Result on solid blocks from different manufactures

Manufactures	Block Dimension(mm)	Age (Days)	Peal load (kN)	Compressive Strength (N/mm²) Individual Unit	Compressive Strength (N/mm²) Average of 3 blocks
	450×150×225	21	104.625	1.55	
A	450×150×225	21	86.400	1.28	1.61
	450×150×225	21	134.325	1.99	
	450×150×225	21	161.700	2.40	
B	450×150×225	21	118.900	1.76	2.24
	450×150×225	21	174.925	2.59	
	450×150×225	21	172.800	2.56	
C	450×150×225	21	157.375	2.33	2.40
	450×150×225	21	155.350	2.30	
	450×150×225	21	130.175	1.93	
D	450×150×225	21	119.475	1.77	1.97
	450×150×225	21	149.175	2.21	
	450×150×225	21	153.225	2.27	
E	450×150×225	21	126.800	1.88	1.97
	450×150×225	21	118.800	1.76	
	450×150×225	21	172.800	2.56	
F	450×150×225	21	183.850	2.72	2.55
	450×150×225	21	159.275	2.36	
	450×150×225	21	153.225	2.27	
G	450×150×225	21	164.700	2.44	2.42
	450×150×225	21	171.275	2.54	
	450×150×225	21	150.160	2.22	
H	450×150×225	21	165.500	2.45	2.47
	450×150×225	21	184.175	2.73	

	450×150×225	21	138.950	2.06	
I	450×150×225	21	182.250	2.70	2.24
	450×150×225	21	132.975	1.97	
	450×150×225	21	154.425	2.29	
J	450×150×225	21	149.075	2.21	2.17
	450×150×225	21	135.675	2.01	
	450×150×225	21	110.43	1.64	
K	450×150×225	21	103.10	1.53	1.61
	450×150×225	21	111.76	1.66	
	450×150×225	21	136.41	2.02	
L	450×150×225	21	144.82	2.15	1.94
	450×150×225	21	110.78	1.64	
	450×150×225	21	133.60	1.98	
M	450×150×225	21	120.10	1.78	1.86
	450×150×225	21	122.90	1.82	
	450×150×225	21	143.70	2.13	
N	450×150×225	21	156.33	2.32	2.17
	450×150×225	21	138.40	2.05	
	450×150×225	21	103.01	1.53	
O	450×150×225	21	118.11	1.75	1.61
	450×150×225	21	105.61	1.56	
	450×150×225	21	76.34	1.13	
P	450×150×225	21	80.19	1.19	1.12
	450×150×225	21	70.00	1.04	
	450×150×225	21	166.70	2.47	
Q	450×150×225	21	193.52	2.87	2.73
	450×150×225	21	191.65	2.84	
	450×150×225	21	118.60	1.76	
R	450×150×225	21	142.55	2.11	1.90
	450×150×225	21	122.60	1.82	
	450×150×225	21	156.44	2.32	
S	450×150×225	21	130.75	1.94	2.15
	450×150×225	21	147.05	2.18	

	450×150×225	21	183.44	2.72	
T	450×150×225	21	177.10	2.62	2.67
	450×150×225	21	180.44	2.67	
	450×150×225	21	203.73	3.02	
U	450×150×225	21	210.30	3.12	3.09
	450×150×225	21	211.22	3.13	
	450×150×225	21	119.80	1.78	
V	450×150×225	21	137.94	2.04	1.87
	450×150×225	21	120.62	1.79	
	450×150×225	21	184.73	2.74	
W	450×150×225	21	210.49	3.12	2.93
	450×150×225	21	194.76	2.95	
	450×150×220	21	204.20	3.03	
	450×150×220	21	194.72	2.89	2.95
X	450×150×220	21	197.49	2.93	
	450×150×220	21	177.33	2.63	
	450×150×220	21	162.10	2.40	2.51
Y	450×150×220	21	168.45	2.50	
	450×150×225	21	192.60	2.85	
	450×150×225	21	188.35	2.79	2.84
Z	450×150×224	21	194.23	2.88	
	450×150×220	21	122.35	1.85	
	450×150×221	21	126.13	1.91	1.92
A1	450×150×220	21	131.47	1.99	
	450×150×225	21	177.43	2.63	
	450×150×225	21	163.37	2.42	2.47
A2	450×150×225	21	160.14	2.37	
	450×150×225	21	170.23	2.52	
	450×150×225	21	157.00	2.33	2.44
A3	450×150×225	21	166.39	2.47	
	450×150×225	21	104.31	1.55	
A4	450×150×225	21	101.66	1.51	1.51
	450×150×225	21	98.72	1.46	

Appendix B:

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COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

FACULTY OF TECHNICAL EDUCATION

DEPARTMENT OF CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION

QUESTIONNAIRE

This questionnaire seeks to gather relevant information for a study into the standard of precast sandcrete blocks produced by the commercial manufacturers in Sekondi-Takoradi. The study is strictly for academic purposes and as such the confidentiality of every bit of information provided is guaranteed.

Instructions: *Please tick [√] the most appropriate answer(s) or provide the appropriate response(s), where applicable, to each of the following questions.*

Section A: Demographic Characteristics

1. How many years has this company been in business?

i. Less than a year [ ] ii. 1-5 yrs. [ ] iii. 6-9 yrs. [ ] iv. 10 yrs. or more [ ]

2. What is your position?

i. Owner [ ] ii. Manager [ ] iii. Supervisor [ ] iv. Operative [ ]

Section B: Manufacturing of Blocks

3. What type of blocks do you produce? *Tick as many as applicable*

i. Solid [ ] ii. Hollow [ ] iii. Cellular [ ]

4. Which of these types of cement do usually you use making your blocks?

i. Portland Cement (PLC) [ ] ii. Rapid Portland Cement (RHPLC) [ ] iii. Super Rapid

Portland Cement (SRHPLC) [ ] iv. Other (specify) ……………

5. Which of these types of sand do you use for your blocks? *Tick as many as applicable*

i. River sand [ ] ii. Pit sand [ ] iii. Quarry dust [ ] iv. Sea sand [ ] v. Other (specify) ……

6. Which type of water do you use for making your blocks? *Tick as many as applicable*

i. Treated [ ] ii. Untreated [ ] iii. Rain [ ] iv. Well [ ] v. Other (specify) …………

7. What is the ratio of cement and sand that you usually use for your blocks?

i. 1:6 [ ] ii. 1:8 [ ] iii. 1:10 [ ] iv. 1:12 [ ] v. 1:14 [ ] vi. Other (specify) …………

8. How many days do you usually use to cure the blocks?

i. 1-4 days [ ] ii. 5-9 days [ ] iii. 10-14 days [ ] iv. Others (specify) ………………….

Section C: Quality Assurance of Blocks

9. Is there supervision during the production of the blocks?

i. Yes [ ] ii. No [ ]

10. Does the Standard Board often call in to take samples for test?

i. Yes [ ] ii. No [ ]

11. Do you send samples of your product for test?

i. Yes [ ] ii. No [ ]

12. What are some of the difficulties you encounter in producing your blocks?

…………………………………...………………….……………………………………

……………………………………………………………………………………………

13. Any suggestions:

……………………………………………………………………………………..……….

..……………………..………………………………………………………………………

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DEPARTMENT OF CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION

OBSERVATIONAL GUIDE

Instructions: *Please observe the following manufacturing practices and record your observations as appropriate as possible*

1. The quality of sand use:

i. Silt free [ ]   ii. Free from organic impurities [ ]   iii. Free from silt and organic impurities [ ]

2. Method of mixing: i. Mechanical [ ]   ii. Manual [ ]

3. Type of equipment use for moulding: i. Machine [ ] ii. Moulding box [ ]

4. Method of compaction: i. Mechanical [ ]   ii. Manual [ ]

5. Method of storage: i. Open air [ ]   ii. Undercover [ ]

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

A STUDY INTO THE STANDARD OF PRECAST SANDCRETE BLOCKS PRODUCED BY THE COMMERCIAL MANUFACTURERS IN SEKONDI/TAKORADI METROPOLIS

SELASSIE KOFI FIAHAGBE

DECEMBER, 2018