EFFECT OF COARSE AGGREGATE GRADATION ON THE COMPRESSIVE STRENGTH OF A CONCRETE

BY

AGBODO KINGSLEY CHUKWUEBUKA

2016224065

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD

BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN CIVIL ENGINEERING

SUBMITTED TO THE

DEPARTMENT OF CIVIL ENGINEERING DEPARTMENT

FACULTY OF ENGINEERING

NNAMDI AZIKIWE UNIVERSITY, AWKA

SUPERVISOR: ENGR. DR. P.O ONODUAGU.

MAY, 2023.

CERTIFICATION

This is to certify that I AGBODO KINGSLEY CHUKWUEBUKA with the registration number 2016224065 personally, carried out this project till completion for the award of Bachelor's degree in Engineering (B.Eng) department of civil Engineering Nnamdi Azikiwe University Awka. This work to the best of my knowledge has not been submitted for same purpose in the field of civil Engineering.

....
..

Agbodo Kingsley Chukwuebuka Date

APPROVAL

This research work has been assessed and approved by the Department of Civil Engineering, Nnamdi Azikiwe University Awka.

....

Engr.Dr.P.O Onoduagu Date

Supervisor

....

Engr.Dr Celestine Ezeagu Date

Head of Department

....

External Examiner Date

DEDICATION

I dedicate this work to the SUPREME BEING whom His infinite grace and mercy has lead me to the successful completion of this project. And also to my parents MR. AND MRS.ERNEST AGBODO, my brothers and sisters for their individual prayers and love, also to Ojiako Esther Chibuoñum for her love and words of encouragement towards the success of this work and to the entire members of my family.

ACKNOWLEDGEMENT

I thank the ALMIGHTY GOD, the pioneer of knowledge and wisdom, for his Mercy and Grace upon me.

I will never stop thanking my parents Mr. and Mrs. Ernest Agbodo who has vowed never to seize their support towards my successful achievement of my formal Education, may God bless them all.

I owe much gratitude to my Uncle and Aunt Nwachukwu Peter and Agbo Christiana for their immense support, prayers and encouragement, and to my wonderful sister AGBODO SARAH for her prayers for me.

My endless gratitude to my wonderful Supervisor Engr. Dr. P.O Onoduagu and to all my lecturers for the knowledge they have impacted and the mentorship during the course of this program; Engr. Prof. C.H. Aginam, Engr. Prof. C.M.O Nwaiwu, Engr. Prof. (Mrs) N.E Nwaiwu, Engr. Dr. C.A Ezeagu, Engr. Dr.B Adinna, Engr. Rev. Dr. C.M Nwakaire, Engr. Mr. and Mrs Nwajiaku, Engr. Frank, Engr. Ubani and Engr. Mrs Nkechi and to all other lectures and staff of the department

I wish to thank my loving and assisting course mates Elias Goodluck and Chukwuemeka for their wonderful company.

May God bless you all, Amen.

TABLE OF CONTENTS

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

ABSTRACT

This project was used to investigate the effect of coarse aggregate gradation on the compressive strength of concrete from the three samples of granites gotten from Agu-Awka round About of 20mm,10mm and 25mm coarse

aggregate, which was left to dry and was tested with sieve analysis as the preliminary test in order to determine the particle size distribution. The workability (slump) of the concrete was carried out through a slump test of which the apparatus used are Anamel tray, hand trowel, shovel, slump cone, head pan, metallic tape, tamping rod of 25blows on each layers of three fills and a weight balance. The weight of the sample of the fine aggregate used was 300kg, the weight of the sample for 10mm coarse aggregate used was 2000kg, the weight of the sample for the 20mm coarse aggregate used was 2000kg, the weight of sample for the 25mm coarse aggregate used was 2000g.With the mixing ratio of water to cement ratio of 1:2:4. The slumps obtained are in the range of 15mm to 88mm.The highest slump was obtained at concrete A6 which is 25mm and 10mm coarse aggregate. The Compressive strength of six cubes of concrete made by using three different coarse aggregate (20mm and 10mm),(10mm and 25mm) in a mixed proportion, then the third size which is 25mm.The Compressive strength of one from each of the cube groups were monitored and crushed at the range of 7days and 28days by a Compressive testing machine. The Compressive strength of the concrete was determined by the automatic Compressive testing machine when at the 7th day of curing a test load of 305.28KN was confirmed to crush a cube of (10mm and 20mm) concrete with a strength of 13.50N/MM^2, A test load of 345.41KN was confirmed to crush a cube of 25mm at a strength of 15.35N/MM^2, A load of 416.25KN was confirmed to crush a cube of (10mm and 25mm) at a Compressive strength of (18.50N/MM^2). On the 28th day of curing a test load of 426.06KN was confirmed to crush second cube of 10mm and 20mm at a Compressive strength of 18.93N/MM^2. A load of 460.06(KN) was confirmed to crush a cube of (25mm) at a Compressive strength of 20.40N/MM^2. And a test load of 573.75KN was confirmed to crushed a cube of (10mm and 25) at a Compressive strength of 25.50N/MM^2. In conclusion, it is now made to be known through the research made that the Compressive strength of a concrete can be determined from the Gradation (proportions) used and the smaller the size of an aggregate, the increase in the water/cement ratio which causes reduction effect on the Compressive strength of the concrete and the larger in size of a coarse aggregate present in a concrete mix, the Compressive strength which is also in agreement with the findings of Vilane, B.R and Sabelo (2016). That is to say, increase in water ratio beyond the proper proportion, Amateur curing of concrete and smaller in size of a course aggregate during Gradation, affect the Compressive strength of a concrete.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. Concrete is the second-most-used substance in the world after water and is the most widely used building material. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Gagg, (1may 2014) globally, the ready-mix concrete industry, The largest segment of the concrete market, is projected to exceed $600 billion in revenue by 2025, Which is equivalent to #276,198,000,000.00 in Nigeria. This widespread use results in a number of environmental impacts. Most notably, the production process for cement produces large volumes of greenhouse gas emissions, leading to net 8% of global emissions. Other environmental concerns include widespread illegal sand mining, impacts on the surrounding environment such as increased surface runoff or urban heat island effect, and potential public health implications from toxic ingredients. Significant research and development are being done to try to reduce the emissions or make concrete a source of carbon sequestration, and increase recycled and secondary raw materials content into the mix to achieve a circular economy. Concrete is expected to be a key material for structures resilient to climate disasters, as well as a solution to mitigate the pollution of other industries, capturing wastes such as coal fly ash or bauxite tailings and residue.

When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The cement reacts with the water through a process called concrete hydration that hardens over several hours to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. National Highway Institute. Portland Cement Concrete Materials (PDF). Federal Highway Administration. Archived (PDF) from the original on 9 October 2022.This time allows concrete to not only be cast in forms, but also to have a variety of tooled processes preformed. The hydration process is exothermic, which means ambient temperature plays a significant role in how long it takes concrete to set. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix, delay or accelerate the curing time, or otherwise change the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete.

In the past, lime based cement binders, such as lime putty, were often used but sometimes with other hydraulic cements, (water resistant) such as a calcium aluminate cement or with Portland cement to form Portland cement concrete (named for its visual resemblance to Portland stone). Many other non-cementitious types of concrete exist with other methods of binding aggregate together, including asphalt concrete with a bitumen binder, which is frequently used for road surfaces, and polymer concretes that use polymers as a binder. Concrete is distinct from mortar. Whereas concrete is itself a building material, mortar is a bonding agent that typically holds bricks, tiles and other masonry units together.

The strength of concrete, depends very much on the aggregates type, size and source. Aggregates amount to at least three quarters of the volume of normal weight of concrete and they are cheaper than cement and also confer a considerable better durability. The aggregates are divided into two major parts

The fine are aggregates not larger than 5mm while coarse aggregate are sizes of at least 5mm.Aggregate properties on concrete like grading of aggregates depends on proportion. If grading of aggregate is varied, it also changes cement content, cost economy, workability of the mix and porosity.

It is an important factor and has a maximum influence on workability. Well graded aggregate results in the least amount of voids in a given volume. Less void results in excessive paste availability in the unit volume and more lubrication. Hence the mix is cohesive and avoids segregation.

Note that coarse aggregate makes up about 75% of concrete by volume. Strength of concrete is also affected by the properties of course aggregates besides water cement ratio and other properties. Lightweight aggregate concrete may be more influenced by the compressive strength of the aggregate. Coarse aggregate is usually greater than 4.7mm (retained on a no.4 sieve) which account for 60 to 80 percent of the weight of the concrete. Normal aggregate like chippings, granite, gravel, limestone and sand stone are mostly used in modern civil engineering project. Coarse aggregate defines the concrete thermal and elastic properties and dimensional stability. Coarse aggregate used in concrete making contains aggregates of various sizes. This particle size distribution of the coarse aggregate is termed as GRADATION. The sieve analysis is conducted to determine the particle size distribution of a soil.

Each type of the gradation has a certain influence on the concrete properties. The type of aggregate grading employed is as a result of a particular mix yields, higher strength, lower shrinkage and greater durability. Meanwhile, It is advisable to make a right choice in selecting a certain size of aggregate that will be suitable for a particular type of concrete work. Even most of the properties exhibited by concrete are what is made up of aggregate.

1.2 Problem statement

At times, concrete after being produced and cured shrinkage and cracked, deformed and creped under tension by applied load before its due time. When such thing happens it means, that the concrete has failed in various ways, especially in its compressive strength which in turn depends on the size of coarse aggregates used for that particular concrete. Poor compressive strength of concrete is at times due to little or no hydration of the concrete.

As a workable concrete is said to be concrete suitable for placing and compacting under the site condition, mostly in concrete production, an end product of maximum strength and good workability is expected, which implies that when can suitable size of coarse aggregate is used, it means, there is bound to be a compromise in the concrete initial expected properties. In avoiding such problem, it is then imperative that right size of coarse aggregate is employed during concrete work since a certain categories of aggregate grading has a certain effect on concrete properties.

The proposed research will attempt to determine the suitable grading of coarse aggregate that will bring out the best properties in concrete.

1.3 Aim of Study

The aim of this research is to determine the effect of coarse aggregate gradation on the compressive strength of concrete.

1.4 Objective of the Study

i. To determine through the experiment which particular size of the coarse aggregate that gives a concrete the best properties

ii. Obtaining through some laboratory test the optimum compressive strength and workability of concrete by using different sizes of a particular coarse aggregate.

iii. To research more on the nature of concrete.

iv. Knowing the characteristic behavior of coarse aggregate gradation.

1.5 Relevance of Study

The study is so crucial in various dimensions, it is academically impressive and timely the contribution of the research to the academic setting is that it will serve as a memorandum to further research on the areas of concrete technology and properties of concrete in terms of grading. As it will serve as a source of data for researchers on field knowledge.

1.6 Scope of Work

This research work was limited to the effect of aggregate grading at varying percentage in different concrete mix, which is related to workability and compressive strength properties of the resulting concrete only.

1.7 Limitations of Work

This research was localized around Nnamdi Azikiwe University Awka, due to the knowledge level of the researcher to necessary data and resources for more detailed research.

i. The money to convey the aggregates from the seller's shop to the lab was too expensive due to high rate of fuel price which is one of the limitations of the work.

ii. The unavailability of much equipment especially, when there are many researchers in the lab.

CHAPTER TWO

REVIEW OF RELATED LITERATURE.

A literature review on the effect of aggregate grading on the qualities of concrete was presented in this chapter.

2.1 Overview of concrete.

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens,(cures) overtime. Concrete is the second most used in the world after water and is the most used building materials. The paste, composed of Portland cement and water, coat the surface of the fine and coarse aggregate through a chemical reaction called HYDRATION, the paste hardens and gains strength to form the rock like mass known as concrete.

2.2 Concrete Components and Mixes

Concrete is made up of two components, aggregates and paste. Aggregates are generally classified into two groups: Fine and coarse and occupy about 60 to 80 percent of the volume of concrete. The paste is composed of cement, water, and entrapped air and ordinary constitutes 20 to 40 percent of the total volume.

Mass concrete and reinforced concrete are composite materials. Mass or plain concrete is made up of cement or lime, fine and coarse aggregate and water. Reinforced concrete incorporates steel, although wrought iron was used in the earliest reinforced structures before 1900.The cement or lime is used as an adhesive to bind the coarse and fine aggregate. Water is added after dry mixing, which starts a chemical reaction with the cement or lime, resulting in a fluid mixing that hardens into a solid mass with good compressive strength but poor tensile strength.

2.2.3 Cement

Cement is a binder, a chemical substance used for construction that sets, hardens and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is behind only water as the planet's most consumed resources.

Plate 2.1

2.3 Unmixed Cement

Portland cement is the basic ingredient of concrete. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Common material used to manufacture cement include limestone, shells, and chalk or mark combined with shale, clay, slate, blast furnace, slay silica sand and iron ore. These ingredients when heated at high temperatures form a rock-like substance that is ground into the fine powder that we commonly think of as cement.

Bricklayer Joseph Aspdin of leads England first made Portland early in the 19th century by burning powdered limestone and clay in his kitchen stove. With this crude method, he laid the foundation for an industry that annually processes literally mountains of limestone, clay, cement rock and other materials into a powder so to pass through a sieve capable of holding water.

Cement used in construction are usually inorganic often lime or calcium silicate based, which can be characterized as Hydraulic or the less common Non-hydraulic depending on the ability of the cement to set in the presence of water.

2.3.1 Hydraulic cement (eg Portland cement) set and become adhesive through a chemical reaction between the dry ingredients and waters the chemical reaction result in mineral hydrates that are not very water soluble and so, are quite durable in water and safe from chemical attack. This allows setting in wet condition or under water and further protects the hardened material which was found by ancient Romans who used volcanic ash (pozzolana) with added lime (calcium-oxide).

2.3.2 Non-hydraulic cement (less common) does not set in wet condition or under water. Rather, it sets as it dries and reacts with Carbon dioxide in the air. It is resistant to attack by chemical after setting. The word "CEMENT" can be traced back to the Ancient Roman term OPUS CAEMENTICIUM, used to describe masonry resembling modern concrete that was made from cruised rock with burnt lime as binder. The volcanic Ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to as CEMENTUM, Cimentum, Cement and cement time. Organic polymers are sometimes used as cement in concrete.

World production of cement is about four billion tonnes per year, of which about half is made in China. If the cement industry were a country, it would be the third largest carbon dioxide emitter in the world with up to 2.8billon tonnes, surpassed only by China and the United State. The initial calcination reaction in the production of cement is responsible for about 4%of global C02 emissions, as the cement kiln in which the reaction occurs is typically fired by coal or petroleum coke because, a luminous flame is required to heat the kiln by radiant heat transfer. As a result, the production of cement is a major contributor to climate change.

2.4 Chemical Properties of Cement.

Four major oxide are (Ca0,Si02,Al203 and Fe203) occupy the volume of cement (90%)the main chemical content of Portland cement are tabulated below:

Chemical properties of Portland cement (Gamage et al 2011):

Chemical content.
Amount

Calcium oxide (Cao)	60-67
Silicon dioxide (Sio_2)	17-25
Aluminum oxide(Al_20_3)	3-8
Iron oxide (Fe_20_3)	0.5-4
Magnesium oxide (Mg0)	0.1-4
Sodium oxide (Na_20)	0.2-1.3
Potassium Oxide (K_20)	0.2-1.3
Sulphur Trioxide ($S0_3$)	1-3

2.4.1Aggregate:

Are inert granular materials such as sand gravel, or crushed stone that's along with water and Portland cement are an essential ingredients in concrete. Aggregate materials; are sand, gravel, crushed stone, slag etc.

Aggregates are of two types which include: Coarse and fine aggregate. The aggregate of each type is further subdivided into many types and classification based on their sizes. The technique of series analysis is used for gradation of aggregate for use in concrete and for other applications. The coarse grained aggregate, will not pass through sieve with 4.75mm opening (No.4)

Plate 2.02. **Plate 2.03.**

2.4.2 The Fine Aggregate

Are those particles passing the 9.5mm(3/8mm) in sieve almost entirely passing the 4.75mm No.4sieve and predominantly retained on the 75um (No.200).Note that for increase workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate: To fill the void in the coarse aggregate and to act as a workability agent. Increase in the maximum size of aggregate will increase durability by decreasing the cement paste content that will be under the physical or chemical attacks (mindes, et al 2003).Use of hard dense and strong aggregate will improve durability by providing good wear resistance.(IMCP2006:Mindess,et al, 2003) And again, aggregate should be free of reactive silica that causes a chemical reaction between the alkali in the aggregates because, alkali silicate reaction is very damaging for concrete and it significantly decreases the durability of concrete by causing map cracking, pop out and staining Mindness et al (2003). Although the importance of using clean aggregate gradually began to be understood in the 1800s, It is unlikely that the use of clean aggregate that were free from clay coatings, organic materials or sea salts was always ensured in early concrete. The consequences of using dirty aggregate includes a tendency to attract and retain water, poor setting and curing, and chemical reactions that results in corrosion of the reinforcing and accumulation of efflorescence on the concrete surface. For many builders, economic considerations and the reality of working in a country with a rudimentary land based transport infrastructure would have meant that the most likely sources of aggregate were those that were locally available.

The most commonly used aggregates came from stream and gravel pits, and often includes sea sand and shells. Grading and size of aggregate both affect the amount of water needed to obtain workability. Generally, about 30% of the volume of well graded sand is void, which means that 30% of this volume of cement binder will be required. This explains the commonly used proportion of 1:3 binder to sand ratio often used in mortar specifications. This is a useful guideline for mixes in general, unless the historic mortar is known to have had a different binder aggregate ratio. The shape of the aggregate will also affect the workability of the concrete. An extremely rough, angular aggregate is less workable and may require more water to be added to the mix to increase it workability, thus reducing strength and producing a more porous concrete. Sharp aggregate can also hinder compaction. It does however, bond well with the cement paste to produce a stronger concrete. Therefore, a balance between rounded and sharp aggregate is desirable, ideally, aggregate should have a compressive strength equally to that of the cement paste should be chemically inert in water, and should be clean, hard and free from clay coatings and organic materials to ensure a good bond with the cement.

2.4.3 Effect of Coarse Aggregate on Concrete

Several factors are known to influence the strength of concrete. They include their batch ratio‹process, aggregate texture, shape of other constituents material,(woode, Amoah, Aguba and Ballow, 2015). Aggregates are mixture of various sizes of stone or rock particles in contact with each other. They are typically combination of gravel and crushed jeetendra prajapet, Department of Civil Engineering, Libali-08). Nepal Email:jeeten. Aggregate was originally viewed as inert, inexpensive material dispersed throughout the cement paste so as to produce a larger volume of concrete in fact, aggregate is not truly inert because it's physical, thermal and sometimes, chemical properties influences the performance of concrete.(Neville and Brooks,2010). Many studies have been made to determine the effect of the physical and chemical properties of aggregate on the behavior of concrete. They include investigations into the effect of particle strength, surface texture, and shape and alkali reactivity. Findings indicate that aggregate plays a more active role than was previously believed and a better understanding will result from further research (Stensater,1963).The compressive strength of fresh and hardened concrete is greatly affected by the type of coarse aggregate being used in concrete mixing. Since coarse aggregate occupies major volume in concrete, the overall property of coarse aggregate affect the property of concrete produced with different normal mix. The properties of coarse aggregate are governed by their source, size, shape, unit weight, texture eye. Coarse aggregate properties (geological, physical and mechanical) are influenced by the source from which they have been recovered.

The variation on the aggregates properties (either mechanical or physical) also affects the property of concrete strength, workability and durability. There is significant influence of difference aggregate types on concrete compressive strength, with stronger aggregate types increasing the overall strength of the concrete (1995: Larrard & Belloc, 1997). Aggregate characteristics like shape, texture, and grading influence workability, furnish ability, bleeding, pumpability, and segregation of fresh concrete and affect strength, stiffness, shrinkage, creep, density, permeability and durability of hardened concrete (lafrenz,1997).The study on effect of content and particle size distribution of coarse aggregate on the compressive strength of concrete revealed that compressive strength is strongly linked to the coarse aggregate parameters (content, proportion of fine to coarse aggregate and grain size distribution of concrete mixture (Mohammed, salm & said 2010). Sahin etalin 2003 also observed that the increase in strength for a given increase in cement content depends on the type of aggregate used and the cement content itself while OZTURAN & CECEN (1997) have found that for the same properties of paste, different types of coarse aggregate with different shape, texture, mineralogy and strength may result in different concrete strength. In research on the effect of aggregate content on the behavior of concrete, Ruiz (1966) found that the compressive strength of concrete increases in coarse aggregate content, up to a critical volume of aggregate and then decreases. In 1947, Glanville et All, has expressed the opinion that the shape, texture and porosity of aggregate affect concrete workability.

2.4.4 Gradation of Aggregate.

According to Haseeb Jamal, (Oct 5, 2019). Says that the particle size distribution of an aggregate as determined by size analysis is termed as **Gradation of Aggregates**. If all the particles of uniform size, the compacted mass will contain more voids whereas aggregate comprising particles of various sizes will give a mass with lesser void. The particle size distribution of a mass of aggregate should be such that the smaller particles fill the void between the larger particles. The proper grading of an aggregate produces dense concrete and needs less quantity of fine aggregate and cement waste, therefore, it is essential that coarse & fine aggregates be well graded to produce quality concrete. In general, if the water-Cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength.

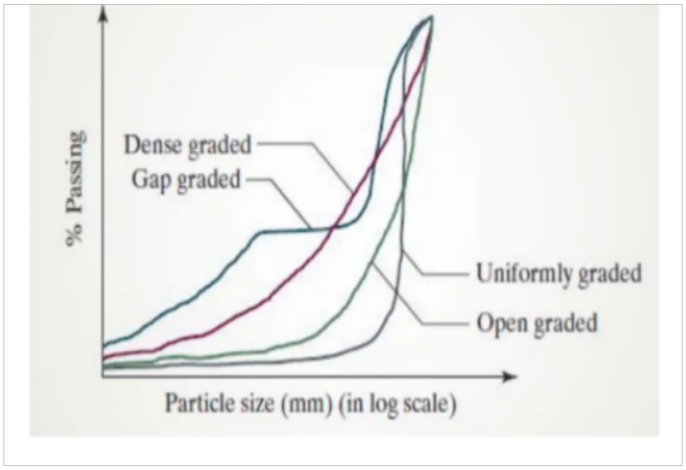


Figure 2.1 by (Haseeb Jamal/on: Oct 05,2019

Grading Curve of Aggregate

2.4.5 Grading Curve of Aggregate.

The grading of aggregate is represented in the form of a curve or an S-CURVE. The curve showing the cumulative percentage of the material passing the sieve represented in the ordinate with the sieve openings to the logarithmic scale represented on the Abscissa is termed as GRADING CURVE.

2.5.1. Types of Aggregates

i. Dense or well graded Aggregate: Has gradation close to the FWHA maximum density grading curve.

ii. Gap-graded Aggregate: Has only a small percentage of particles in the mid-size rang.

iii. Uniformly graded aggregate-composed mostly of particles of the same size.

iv. Open graded aggregate-Contains only a small percentage of small size particle.

The optimization of aggregate gradation improves the rheological, mechanical and durability properties of concrete. Segregation in plastic state under vibration particularly is the most vulnerable problem in concrete containing aggregate with poor gradation.

Aggregate in concrete, being much stiffer than the hardened cement paste, act to resist the shrinkage behavior of concrete. Aggregate gradation which determines the relative proportion of aggregate and cement paste in a concrete therefore, dictates the shrinkage behavior of concrete and hence long term durability of concrete. The proper grading of an aggregate produces dense concrete and needs less quantity of fine aggregate and cement waste therefore, it is essential that coarse and fine aggregates be well graded to produce quality concrete.

2.5.2. Gradation and its Effect in Compressive Strength of Concrete.

Coarse aggregates used in concrete making contain aggregates of various sizes. The sieve analysis was conducted to determine this particle size distribution. Grading pattern is assessed by sieving a sample successively through the entire sieves mounted one over the other in order of size, with larger sieve on the top. The material retained on each sieve after shaking represents the fraction of aggregate coarser than the sieve in question and proper gradation ensures that a sample of aggregate contain all standard fractions of aggregate in required proportion such that the sample contains minimum voids. A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the concrete. Mindess, etc (1981) explained that minimum paste means less quantity of cement and less quantity of water leading to increased economy, higher strength, lower shrinkage and greater durability. The workability is improved when there is an excess of paste above that required to fill the voids in the sand, and also when there is enough water to hydrate the concrete. An excess mortar (sand plus cement) will fill the voids in the coarse aggregate because the fine material lubricates the larger particles. Cement-paste or the matrix that links together the coarse aggregates is weaker than the aggregates. It is this matrix that is vulnerable to all ills of concrete. It is more permeable and is susceptible to deterioration by the attack of aggressive chemicals. Therefore lesser the quantity of such weak link in concrete the better will the concrete be.

This objective can be achieved by having well graded aggregates. Variation in coarse aggregates gradation causes change in the workability of concrete (BS 1881, 1983). There are three typical range categories of aggregate grading, they are; Well Graded, Poor Graded, and Gap Graded. Each of the type of grading has a certain type of effect on the compressive strength of concrete. ACI Committee (1991) rightly argued that well-graded aggregate has a gradation of particle size that fairly evenly spans the size from the finest to the coarsest. A slice of a core of Well - Graded aggregate concrete shows a packed field of many different particles sizes. Well - Graded aggregate is characterized by the S - Shaped in gradation curve. Poor-Graded aggregate is characterized by small variation in size. It contains aggregate particles that are almost of the same size. This means that the particles pack together, leaving relatively large voids in the concrete. It is also called "Uniform- Grade". It is characterized by steep curve. Gap-Graded aggregate consists of aggregate particles in which some intermediate size particles are missing. A core slice of Gap-Graded, or skip size, concrete shows a field of small sized-aggregate interspersed with slightly isolated, large aggregate pieces embedded in a small sized aggregate. It is characterized by a gradation curve with a Jump in between. Montgomery (2001) explained that poor graded concrete generally require excessive amounts of cement paste to fill the voids making them uneconomical. Gap-Graded concrete fall in between Well-Graded and poorly graded in terms of performance and economy. Gap Graded is viable gradation, but not optimal. Well-Graded aggregates are tricky in proportion. The goal of aggregate proportioning and sizing is to maximize the volume of aggregate in the concrete while preserving the strength, workability and finishing. This balance the proportions of each so there are just enough of each size to fill all the voids, while preserving workability and Cast-Surface quality. Neville (1995) explained that some experiments have concluded that grading for maximum density gives the highest strength, and that the grading curve of the best mixture resembles a parabola. However such aggregates graded for maximum density give a harsh concrete that is very difficult in ordinary concreting. So the proportioning should be based on the surface area of aggregates that Is to the wetted. Other things remaining same, it can be said that the concrete made from aggregate grading having least surface area will require least water which will consequently be the strongest. Ozturan and Cecen (1997) showed that generally angular aggregate particles have rough texture and round aggregate particles are smooth textured. From the bonding point of view, it seems that smooth textured rounded particles form a poor bond with cement paste. But the smooth looking surface of rounded particles is also rough enough at the microscopic level and the cement -gel that forms a bond with aggregate surfaces also has particle sizes in the level of microns. Both, surface and the cement gel reacts at the sub-microscopic level.

Angular aggregates have higher specific surface area than smooth rounded aggregate. With a greater specific surface area, the angular aggregate may show higher bond strength than rounded aggregates. Also, angular aggregates exhibit better interlocking effect in concrete that contributes in strength of concrete. Higher specific area of angular aggregates with rough texture demands more water for a given workability than rounded aggregates

2.5.3 Admixture/Additive

Admixture are ingredients other than Portland cement, water, and aggregate that are added to the concrete mixture immediately before or during mixing. They are used to modify certain properties of the concrete and can be classified according to their function

i. Water reducing Admixture.

ii. Retarding Admixtures.

iii. Cement agent.

iv. Workability agent.

v. Air entraining Admixture.

The workability of fresh concrete is also improved with air-entrainment. Regarding Admixtures are used to slow the rate of concrete set or hardening. They are particularly useful for concrete that is placed during hot weather. On the other hand, accelerating Admixture like Calcium Chloride are used to increase the rate of set (hardening) during cold weather.

2.5.4 Water

Water is another essential ingredient in concrete. It is now understood that mixing water should be kept free from salts and other impurities. On occasion, salt, sugar or glycerin was added to mixing water to prevent freezing during cold weather. Although (Marsh 1905) then recommended using fresh water, this indicates that at this time, there was still only a vague understanding that salt might be a problem. Salt in the water have an extremely detrimental effect on reinforced concrete and it is probable that sea water was used in many early structures.

2.5.5 Properties of Concrete During it Plastic State

Workability of concrete:

Workability is a complex property of concrete. The workability of freshly mixed concrete, determines the ease and homogeneity with which it can be mixed, placed and compacted. A good Workability should not show any segregation and bleeding after compaction.

2.6. Segregation of concrete

Plate 2.04. .

2.6.1 Segregation of concrete

Separation of coarse aggregate from the concrete mix is called segregation of concrete. A good concrete should show no to less segregation after mixing. Excessive segregation leads to honey combing and decreasing in the density of concrete and ultimately loss if strength of hardened concrete.

Plate 2.05 **Plate 2.06.**

2.6.2 Bleeding in concrete

Separation of water from freshly mixed concrete is called bleeding. A good concrete should possess no to less bleeding. Bleeding makes concrete porous & weak.

2:6.3 Properties of concrete during it hardened state

The concrete gains 95% of desired compressive strength within 28days by periodic curing. The hardened concrete should possess the following properties.

2.6.4 Compressive strength of concrete grade

The strength of concrete is designated as the characteristic compressive strength of 150mm cube at the age of 28days when tested with the universal testing machine in N/mm^2. As grades of concrete vary between 15 to 80N/mm^2.These grades differ on the basis of mix proportion. Note that, a good concrete should not show less than 19N/mm^2(5%) of compressive strength when tested with UTM after 28days.

2.6.5 Tensile strength of Concrete

Concrete is very low in tension. The tensile strength of concrete is an important property which affects the extent and width of cracks in the structure. A good concrete should have a tensile strength of 1/10 times that of compressive strength.

2.6.6 Tensile strength of Concrete formula [Fcr=0.7√FckN/mm^2] the tensile strength of concrete is calculated experimentally by split cylinder method. The value of tensile strength varies between 1/8 to 1/12 of cube compressive strength.

Grades of Concrete. **Tensile Strength**

M20-M25	2.2N/mm^2
M25-M30	2.6N/mm^2
M30-M35	2.9N/mm^2
M35-M50	3.2-3.5N/mm^2
M50-M60	3.5-4.1N/mm^2

2.7 Modulus of elasticity

Elastic modulus of concrete is an important property required for computation of deflections of structural concrete members.

It is the ratio between stress and strain. Ec=5000√FckN/mm^2.

Grades of Concrete. **Modulus of Elasticity in KN/MM^2**

M20-M25	30
M25-M30	31
M30-M35	32

M35-M50	33-35

2.7.1 Poison ratio

It is the ratio of lateral strain and longitudinal strain. Poisson ratio varies between 0.1 for high strength concrete and 0.2 for weak concrete.

Plate 2.07.

2.7.2 Shrinkage of a concrete

The property of decreasing in volume during the process of drying and hardening of concrete is called shrinkage of concrete. Shrinkage may lead to the surface cracks. An occurrence of shrinkage cracks depends upon the proportion and ingredients of concrete and also environmental conditions.

Types of shrinkage in concrete

i. Plastic shrinkage in concrete

ii. Drying shrinkage in concrete

iii. Autogenous shrinkage in concrete

iv. Carbonation shrinkage in concrete.

Plastic shrinkage

This type manifests itself soon after the concrete is placed in the forms while the concrete is still in the plastic stage.

Dry shrinkage

The dry shrinkage is also an everlasting process when concrete is subjected to drying conditions. The drying shrinkage of concrete is analogous to the mechanism of drying of timber specimen.

Autogenous shrinkage

Where no moisture movement or from the paste is permitted when temperature is constant some shrinkage may occur.

Carbonation shrinkage

Carbon dioxide present in the atmosphere reacts in the presence of water with hydrated cement.

Creep in concrete is defined as the plastic deformation under constant load or stress. Initial creep is rapid at first but approaches a limit after about 5years.The creep is roughly in proportion to the load and is greater in weaker and less mature concrete.

2.7.3 Permeability

All concrete is to some extent permeable, particularly water vapor. Lime concrete, however is much more permeable than modern, general purpose Cement concrete. Well compacted concrete made with a low water. Cement ratio has good resistance to water absorption, but where more water has been used in the mixing, as was often the case in early concrete, the concrete tends to be more porous and hence more permeable. The permeability of early concrete can be a disadvantage where reinforcement was incorporated as this reinforcing is more likely to corrode.

2.7.4 Durability

The ability of concrete to withstand the condition for which it is designated without deterioration for a long period of years is known as Durability or the ability of a concrete to resist weathering action, chemical attack and abrasion while maintaining its desired Engineering properties.

Concrete will be durable if:

i. The cement paste structure is dense and of low permeability
ii. Under extreme condition, it has entrained air to resist freeze-thaw cycle.
iii. It is made with graded aggregate that are strong and inert.

Chemical: As a general principle, the better the compressive strength, the better the chemical resistance. Lime, concrete which is softer and weaker than Portland concrete is more vulnerable to chemical attack. In concrete that has voids and cracks or is porous, reinforcing steel will be more likely to be affected by chemicals and this may result bin corrosion damage to the structure.

Fire: Reinforced concrete is one of the most fire-resistant of common structural material. However, although the strength of ordinary concrete increases up to temperature of 120C, there is a serious loss of strength at high temperature. Flexural strength is more affected than compressive strength because of the effect of heat on steel reinforcing the fire resistance of non-reinforced concrete is slightly lower than that of brick of the same thickness, although the type of aggregate will affect this siliceous Aggregate have the poorest fire resistance, while those that include burnt clay products, pumice, well-burnt clinker, crushed limestone and pelleted fly ash have greater fire resistance. Concrete fails in first because of the differential expansion of the hot exposed layers over cooler internal layer. The insulation that the concrete provides is an important factor in its fire resistance, and lightweight Aggregate concrete performs better in this respect if steel reinforcing is exposed, fire resistance and structural strength reduce dramatically as the rapid condition of heat increases the temperature differential

Appearance: Early concrete structure was often rendered with plaster or clad in a venier of brick or stow where the surface was left untouched after the formwork was removed. The aesthetic effect depended on the inherent colour and texture of the concrete and the quality of the formwork and workmanship. The final colour of concrete depends on the color of concrete as well as that of the aggregate for example, where SCORIA was used for Aggregate, the color of the concrete tended to have a reddish tinge. Early Portland cements were generally lighter in color than modern grey, general purpose Cement.

However, all concrete changes appearance overtime, as the initial cement laitance (Milkiness, i.e fine particles in the surface) weather away from the Aggregate at the surface.

Curing: Concrete that has been specifically batched, mixed, placed and finished can still be a failure if improperly or inadequately cured. Curing is usually the last step in a concrete project and unfortunately, is often neglected even by professionals. Curing has a major influence on the properties of hardened concrete such as durability, strength, water-tightness, wear resistance, volume stability and resistance to freezing and thawing. Proper concrete curing for agricultural and residential applications involves keeping newly placed concrete moist and avoiding temperature extremes (above 90°F or below 50°F) for at least three days. A seven-days (or longer) curing time is recommended if construction constraints permit.

Procedure that prevent the loss of the mixing water from concrete by sealing the surface. This can be the surface and can be done by covering the concrete with impervious paper or plastic sheet, or by applying membrane forming curing compound. The best curing method for a particular job depends on cost application equipment required, materials available, and the size and shape of the concrete surface begins the curing as soon as the concrete has hardened sufficiently to avoid erosion or other damage to the freshly finished surface. This is usually within one to two hours after placement and finishing.

Testing: The extent of testing will depend on the nature of the project, the allocation of funding and the feasibility. This section aims to give those managing the structure a general knowledge of the testing methods that are available to assist in the analysis and evaluation of repairs that may be required. A range of onsite, non-destructive test can be undertaken. Laboratory testing can also be used to supplement the field condition survey and on-site testing as necessary laboratory testing as necessary. Laboratory testing will require samples to be taken on-site. These can be in the form of lump, sawn or core samples. However, core samples may be difficult to obtain on remote sites, as a power source and water are necessary for the use of a core drill. It may also be in appropriate and disfiguring to take such sample from a historic structure.

A well-equipped concrete laboratory can analyse the sample for strength, unit weight, alkalinity, Carbonation, porosity, alkali-aggregate reaction. Presence of Chlorides and past composition. Such test can determine approximate mix proportion and cement content.

Packing density: Given a unit volume filled with particle packing density or packing degree is the volume of solids in its unit volume and is equal to one minus the voids, the packing density gives an indication of how efficiently particles fill a certain volume and for that reason is such an important concept in material science. If high volume of particles can be packed in a certain volume, the necessity for binding which usually is much more expensive, to fill the voids and glue particle will be decreased.

The packing density or packing degree (Hudson, 1999) not only depends on the Aggregate characteristics, but also on the compaction method and on the dimensions of the container. If the sample is just poured, the packing density will be lower than that corresponding to a sample tapped with a rod or a sample vibrated. Unfortunately, a correlation among packing densities obtained using different compaction methods has not been established as it depends on the size, shape and texture of the particles in fact, it is possible that a crushed Aggregate has a lower loose density than a rounded one, while the vibrated density could be the opposite.Other authors prefers compacted packing densities because they are associated with less variability (de larrad, 1999).

CHAPTER THREE

MATERIALS AND METHODS

Three sizes of commercially available chipping aggregates for concrete work was investigated. Normal concrete is being produced from different sizes of aggregates and this imparts different qualities to the resulting concretes. For the purpose of this work, three sizes of aggregate, 25mm, 20mm, and 10mm will be used. The selected aggregates will be spread out for few days before use, to dry, in order to keep the aggregates at surface dry condition.

Normal mix (1:2:4) and water – cement ratio of 0.55mm will be adopted for this work and mix composition to be obtained by weight method. As discussed in literature review, coarse aggregate contributes a lot to the qualities of concrete. Gradation of coarse aggregate in the same hand has great effect also on concrete in the sense that as the sizes of the coarse aggregate differs (along with their physical and mineralogical hardness) so do their qualities in concrete mixture.

3.1 Materials used

Cement: Ordinary Portland cement (Bua Portland cement) was used for this purpose.

Coarse Aggregates: Three different sizes of commercially available chippings; 10mm, 20mm, and 25mm were used.

Fine Aggregate: Sharp river sand obtained from a seller at Agụ Awka.

Water: Water gotten from Civil Engineering concrete laboratory, was used.

3.2 Lists of the Requirements used.

They are; concrete would of dimension 150mm×150mm×150mm, rammer/tamping rod, shovel, head pan, hand towel, BS sieve, weighing balance, mechanical sieve shaker, slump cone, curing tank and Compressive strength testing machine.

3.3 Preliminary Test

I ensured that the aggregates where right ones due to description using sieve analysis.

3.4 Methodology

I investigated the workability through the slump test carried out and compressive strengths of six different concretes made by using three different coarse aggregates (20mm and 10mm),(10mm and 25mm)in a mixed proportions, Then the third size which is 25mm.

By using the three different coarse aggregates, I experimented by casting a total of six different concretes. At a certain mix, and the compressive strength of one from each of the groups monitored and crushed at the range of 7days and 28 days. There were mixtures too in which the 25mm and10mm were brought together and used to prepare concrete while the workability is gotten and compressive strength at 7days and 28days obtained. At these mixtures, the 25mm and 10mm were varied at different percentages. The total six different mixtures were conducted in stages and proportions as shown below:

CALCULATIONS

Parameters

Density of concrete = 2400kg/m

Size of cubes = 150mm × 150mm = 0.15m × 0.15m

Volume of cube = 0.15m × 0.15m × 0.15m

Weight of cube = 2400kg/m ×

Calculating for the individual components using mix ratio 1:2:4 = cement: sand: aggregate

1+2+4 = 7

For cement; 1/7 × 8.1 = 1.157kg

For sand; 2/7 × 8.1 = 2.314kg

For coarse aggregate; 4/7 × 8.1 = 4.629kg

Provide additional 10% on all concrete components to take care of wastage.

Cement = 1.157 + (10/100 × 1.157) = 1.157 + 0.1157 = 1.2727kg

Sand = 2.314 + (10/100 × 2.314) = 2.314 + 0.2314 = 2.545kg

Aggregate = 4.629 + (10/100 × 4.629) = 4.629 + 0.4629 = 5.0919kg

Estimating the weight of water for one cube given that the water cement ratio used is 0.55

Water/cement = 0.55

Therefore weight of water = weight of cement × 0.55 = 1.2727 × 0.55 = 0.7024kg = 0.7024litres

Level 1: for concrete A1 (25mm coarse aggregate + 100% of 10mm coarse aggregate)

At this stage 100% of 10mm coarse aggregate was mixed along with sand, cement, and water to form a concrete since 25mm coarse aggregate was at 0%. Slump test was performed and six cubes were casted.

With a mix ratio of 1:2:4, the concrete's constituents appeared as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

Level 2: for concrete A2 (25% of 25mm coarse aggregate +75% of 10mm coarse aggregate):

At this stage 25% of 25mm coarse aggregate was mixed with the remaining 75% of 10mm coarse aggregate. After the proportioning, the whole aggregates were mixed along with sand, cement, and water to form a concrete. Slump test was performed and six cubes were casted.

With a mix ratio of 1:2:4, the concrete constituents appeared as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

25% of 20mm coarse aggregate = 25/100 × 30.5514 =7.6378kg

Therefore 7.6378kg of 25mm coarse aggregate were used.

75% of 10mm coarse aggregate =75/100× 30.5514kg = 22.9136kg

Therefore 22.9136kg of 10mm coarse aggregate were used.

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

Level 3: for concrete A3 (50% of 25mm coarse aggregate + 50% of 10mm coarse aggregate):

At this stage 50% of 25mm coarse aggregate was mixed with the remaining 50% of 10mm coarse aggregate. After the proportioning, the whole aggregates were mixed with sand, cement, and water to form a concrete. Slump test was performed and six cubes were casted.

With a mix ratio of 1:2:4, the concrete's constituents appeared as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

50% of 25mm coarse aggregate = 50/100 ×30.5514 = 15.2757kg

Therefore 15.2757kg of 25mm coarse aggregate was used

50% of 10mm coarse aggregate = 50/100 ×30.5514 = 15.2757kg

Therefore 15.2757kg of 10mm coarse aggregate were used

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

Level 4: for concrete A4 (75% of 20mm coarse aggregate + 25% of 10mm coarse aggregate)

At this stage 75% of 25mm coarse aggregate was mixed with the remaining 25% of 10mm coarse aggregate. After the proportioning, the two aggregates were mixed together along with sand, cement, and water and prepared as concrete. Slump test was performed and six cubes were casted.

With a mix ratio of 1:2:4, the concrete's constituent appeared as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

75% of 25mm coarse aggregate = 75/100 × 30.5514kg = 22.9136kg

Therefore, 22.9136kg of 25mm coarse aggregate were used.

25% of 10mm coarse aggregate = 25/100 × 30.5514 =7.6378kg

Therefore 7.6378kg of 10mm coarse were used.

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

Level 5: for concrete A5 (100% of 25mm aggregate + 0% of 10mm coarse aggregate)

Here the only coarse aggregate used in concrete mix was 25mm coarse aggregate because 10mm was at 0%. The 25mm coarse aggregate was mixed with sand, cement and water to prepare a concrete. Slump test was performed. Six cubes were casted.

With a mix ratio of 1:2:4, the concrete's materials used were as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

Level 6: for concrete A6 (100% of 25mm coarse aggregate):

At this stage 100% of 20mm coarse aggregate was mixed along with sand, cement, and water to form a concrete. Slump test was performed and six cubes were casted.

With a mix ratio of 1:2:4, the concrete's constituents appeared as follows:

Cement = 1.2727 ×6 = 7.662kg

Sand = 2.545 × 6 = 15.27kg

Total coarse aggregate = 5.0919 × 6 = 30.5514kg

Water = 0.7024× 6 = 4.2144litres =4.2144 ×1000 = 4214.4ml

3.5 Concrete Mixing

Hand mixing method was adopted with trowel in mixing all the various concretes. On a hard-dry concrete floor, the required volumes of all the concrete's constituents needed for a certain concrete mix were measured out, and by using shovel they were thoroughly mixed together. After mixing slump test was taken and finally the concrete was casted into the cubes.

By following the same mixing method, all the individual concretes were mixed, slump tests taken and were casted into cubes.

3.6 Concrete Curing

The test specimens (the concrete cubes) were stored in the laboratory at a place free from vibration for 24hours after which the specimens were removed from the moulds and immediately submerged in a clean fresh water (curing tank). The specimens were left in the curing tank until taken out just prior to the compression test in range of 7 days and 28 days. For accurate result, the water that contained the specimens was renewed every 7days, while the specimens were not allowed to become dry at any time until they were crushed.

3.7 Compression Test

In each selected day for each three concrete cubes to be crushed say; 7days and 28days, they were taken away from the curing tank, weighed over at a weighing scale and the taken to the compression testing machine and sequentially crushed to failure. The average compressive strength of the selected three cubes was taken and recorded as the compressive strength of the cube for a given particular day.

By following the depicted procedures mentioned above and also maintaining the standards the individual concretes made by the three different sized coarse aggregates were worked on and their respective average compressive strengths noted and recorded.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Data Presentation

It is shown in literature review that among other constituents of a concrete such as fine aggregate (sand), and water that coarse aggregate also contribute to the compressive strength of concrete. It is also shown that each individual gradation of a coarse aggregate due to its properties has certain influence on the compressive strength of concrete.

To this end, the study investigated how the sizes (gradations) of a commercially available chippings influence the compressive strength of concrete. Three different sizes 20mm, 10mm and 25mm of the selected chippings were investigated so as to know their effects on the concrete compressive strength.

In order to ensure that high degree of accuracy was achieved, each and every one of the selected gradation was singled out and every phase of the research carried out one after the other. The phases of the experiments were the same for all the gradations.

4.2 ANALYSIS AND RESULTS

Properties of Aggregates

The results for the sieve analysis for the fine aggregate grading for the work is shown below

Weight of sample used = 300kg

Table 4 Showing Sieve Analysis of Fine Aggregate

Sieve size (mm)	**Mass retained (g)**	**Cumulative retained**	**Cumulative % retained**	**Cumulative % Passing**
4.75	1.21	1.21	0.40	99.6
2.00	7.83	9.04	3.01	96.99
1.18	15.44	24.48	8.16	91.84
0.60	225.21	249.69	83.23	16.77
0.30	40.99	290.68	96.89	3.11
0.15	8.64	299.32	99.77	0.23
0.075	0.64	299.96	99.99	0.01
Tray	0.66	300	100	0.00

Graphical Representation of the Fine Aggregate

Looking at fig 4.1, the graph of cumulative percentage passing against the sieve sizes, shows that the fine aggregate is uniformly graded and contains less amount of powdered fine particles and fewer voids, which hinder early strength formation in concrete, therefore it is good for the study.

Various researches and countless practices have shown that a poorly graded fine aggregate is uneconomical in civil engineering practice. Poorly graded fine aggregate will be unstable and always contain lot of voids and due to that excess amount of cement paste are required to fill the voids and therefore requires adequate compaction so as to obtain durable concrete matrix.

Sieve analysis for 10mm course aggregate

Weight of sample used = 2000g

Sieve size (mm)	**Weight retained (g)**	**Percentage retained (%)**	**Cumulative % retained (%)**	**Cumulative % passing (%)**
26.5	0	0	0	100
25	0	0	0	100
20	0	0	0	100
14.0	900	45	45	55
10	1000	50	95	5
4.7	100	5	100	0
Tray	0	0	0	0
Total	2000	100		

SIEVE ANALYSIS FOR 20MM COARSE AGGREGATE

WEIGHT OF SAMPLE USED = 2000g

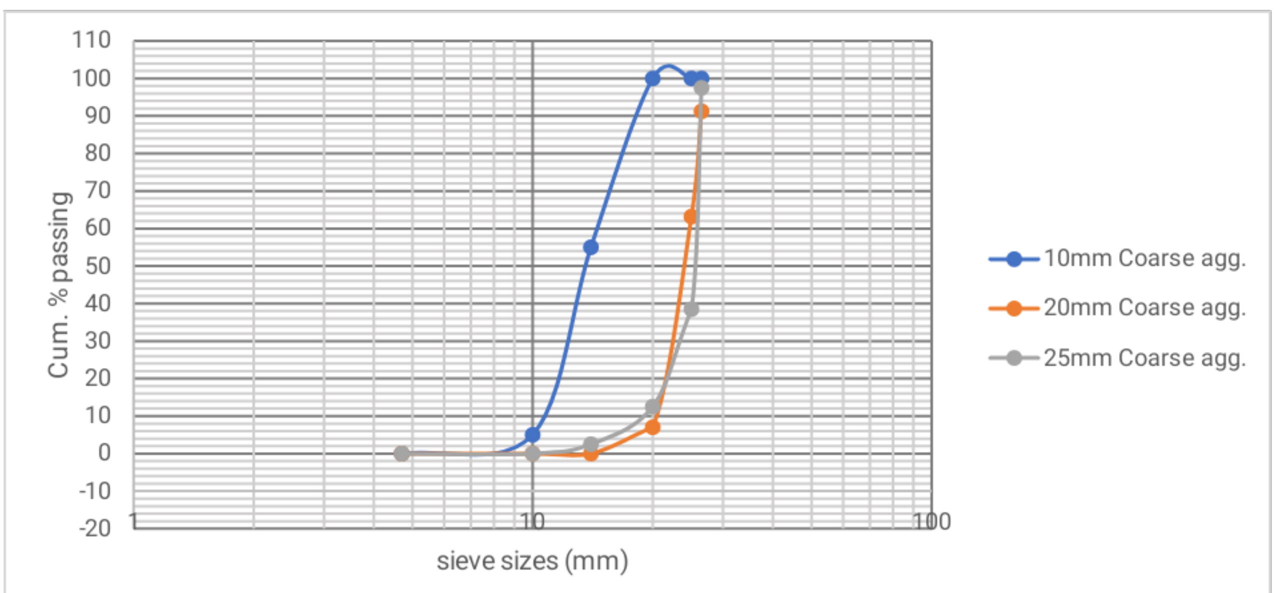
Sieve size (mm)	**Weight retained (g)**	**% weight retained (%)**	**Cumulative % retained**	**Cumulative % passing**
26.5	175	8.75	8.75	91.25
25	561.5	28.08	36.83	63.17
20	1123	56.15	92.98	7.02
14.0	140.5	7.02	100	0
10	0	0	100	0
4.7	0	0	0	0
Tray	0	0	0	0
Total	2000	100		

SIEVE ANALYSIS FOR 25MM COARSE AGGREGATE

WEIGHT OF SAMPLE USED = 2000g

Sieve size	**Weight**	**% weight**	**Cumulative**	**Cumulative %**

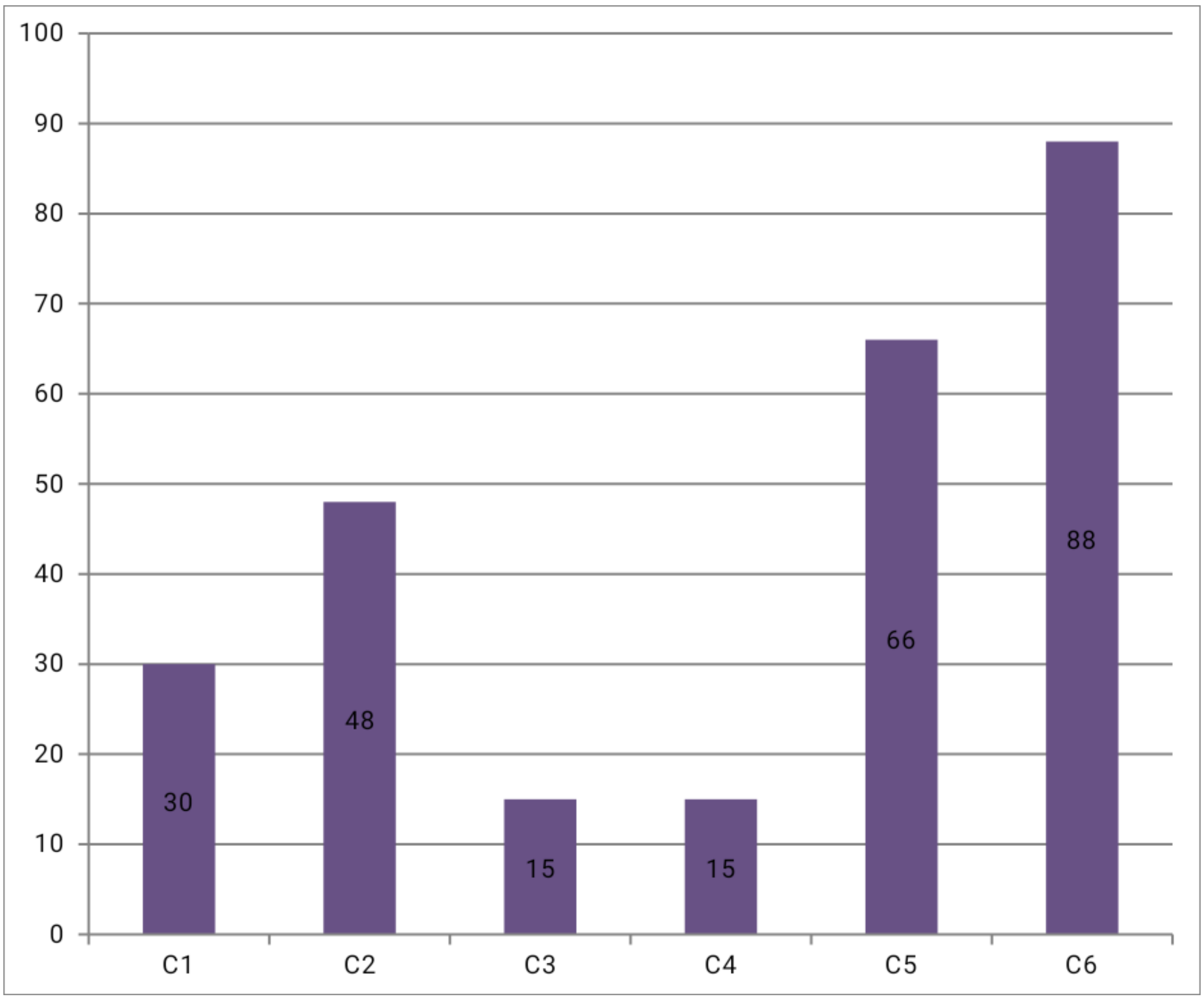
(mm)	retained (g)	retained (%)	% retained	passing
26.5	50	2.5	2.5	97.5
25	1200	60	62.5	38.5
20	500	25	87.5	12.5
14.0	200	10	97.5	2.5
10	50	2.5	100	0
4.7	0	0	100	0
Tray	0	0	100	0
Total	2000	100		



y6

SLUMP

Figure 4.2: Showing the heights of the slumps obtained by the concretes made using the three selected coarse aggregates.



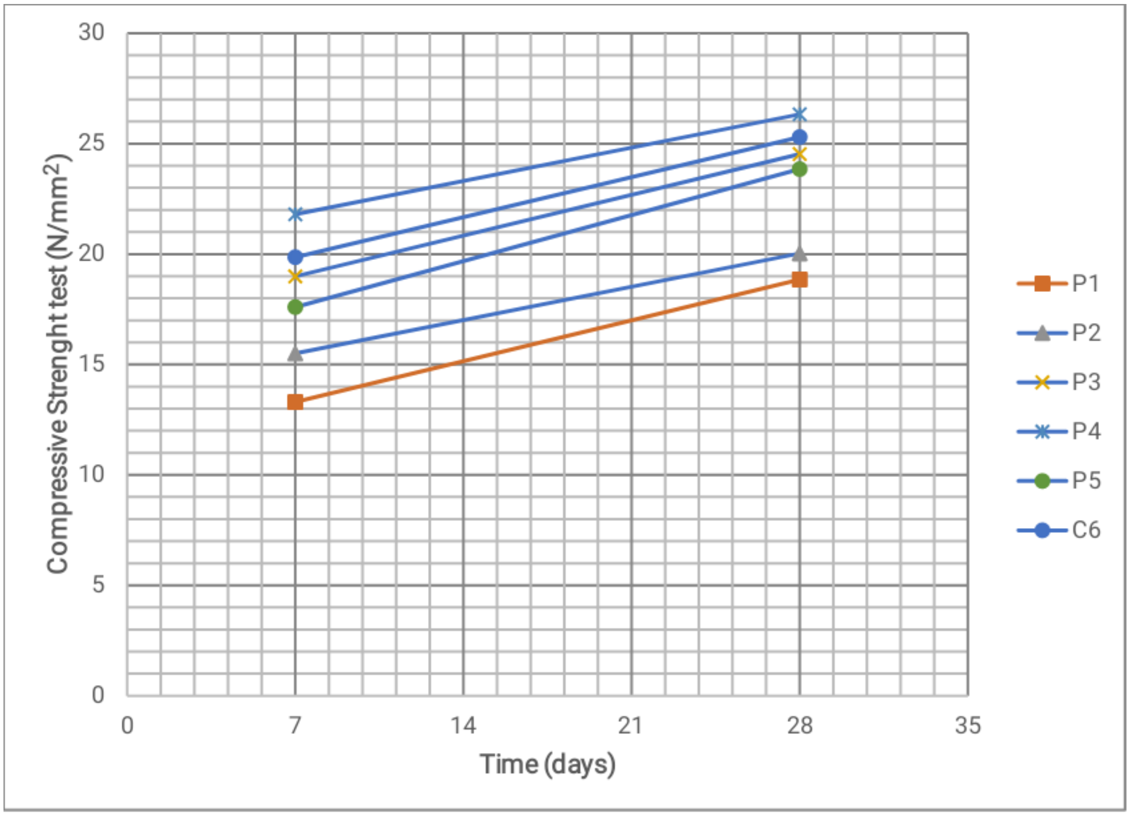
The slumps obtained are in range of 15mm to 88mm. The highest slump was obtained at Concrete A6. At this stage only 25mm coarse aggregate was used. This result is gotten probably due to the mix ratio used (1:2:4).

COMPRESSIVE STRENGTHS OF THE CONCRETE

CUBE Type	Age (days)	Weight of cube (kg)	Test load (KN)	Strength (N/mm^2)	Average strength (N/mm^2)
A1	7	8.7	305.28	13.50	13.85
		8.9	320.40	14.24	
		8.6	310.52	13.80	
	28	8.8	426.06	18.93	18.30
		8.9	386.00	17.16	
		8.7	424.00	18.80	
A2	7	8.2	345.41	15.35	15.50
		8.2	360.00	16.00	
		8.4	340.88	15.15	
	28	8.3	460.06	20.40	20.03
		8.5	450.00	20.00	
		8.3	442.80	19.68	
A3	7	8.7	416.25	18.50	18.99
		8.7	443.25	19.70	
		8.5	422.55	18.78	

	28	8.8	573.75	25.50	24.53
		8.7	575.00	24.80	
		8.6	524.25	23.30	
A4	7	8.2	496.74	22.00	21.80
		8.4	467.04	20.70	
		8.4	510.70	22.69	
	28	8.6	577.80	25.68	26.33
		8.5	617.63	27.45	
		8.5	582.08	25.87	
A5	7	8.5	397.43	17.66	17.60
		8.6	395.54	17.50	
		8.5	386.00	17.20	
	28	8.8	530.66	23.50	23.85
		8.6	554.48	24.64	
		8.8	526.60	23.40	
A6	7	8.3	418.67	18.60	19.86
		8.1	465.56	20.69	
		8.3	456.56	20.29	
	28	8.5	530.66	23.50	25.30
		8.3	580.56	25.80	
		8.6	598.60	26.60	

P1, P2, P3, P4, P5 and P6: Average



Compressive strengths of the cubes for concrete A1, A2, A3, A4, A5 AND A6 respectively.

Looking at the graph above and by comparing the compressive strengths of the concretes made using the three different coarse aggregate. It is seen that the highest compressive strength was achieved by concrete A4 (concrete made of 25% of 10mm and 75% of 20mm coarse aggregate), followed by A6 (concrete made of 100% 20 mm coarse aggregate), then followed by concrete A3 (50% each of 10mm and 25mm coarse aggregate), the next is concrete A5 (concrete made of 100% of 25mm coarse aggregate), concrete A2 came next (concrete made of 75% of 10mm and 25% of 25mm coarse aggregate) and concrete A1 (concrete made of 100% 10mm coarse aggregate) came last.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the comparative workability and strength analysis carried out on the concrete, the following conclusions were made based on the results obtained.

i. The workability of the concrete increases as the water/cement ratio increases in proportion to a given coarse aggregate

ii. I observed that the smaller the size of an aggregate, the Increase in water/ cement ratio which causes reduction effect on the compressive strength of the concrete.

iii. The presence of Large Aggregate sizes resulted in higher strength of the concrete. This suggests that the larger the sizes of coarse aggregate present in a concrete mix, the greater the Compressive strength. This is in agreement with the findings of Vilane, B.R. and sabelo, N. 2016

5.2 Recommendation

i. The use of concrete mix containing large amount of fine aggregate should be discouraged because the workability is poor and there is a lot of void that have adverse effect on the Compressive strength.

ii. The utilization of granite is strongly advised in higher strength concrete applications like in high rise buildings where strength cannot be compromised.

iii. Selecting 10mm sized aggregate in concrete mix when being presented along with 20mm and 25mm sized aggregate since 25mm and 10mm has been found to yield a concrete of higher compressive strength in terms of economy.

REFERENCE

ACI Committee 211. 1-91 (1991), Standard Practice for selecting proportion for normal, Heavyweight and Mass Concrete. Detroit, American Concrete Institute.

Aginam, C.H., Chidolue, C. A and Nwakire, C. (2013), "Investigating the Effects of Coarse Aggregate Types on the Compressive Strength of Concrete", International Journal of Engineering Research and Applications 3(4), 1140-1144.

Aitcin, P., & Mehta, P. (1990). Effect of Coarse Aggregate Characteristics Mechanical Properties of High-Strength Concrete. ACI Materials Journal, 103-107.

Crow, (March 2008). "The concrete conundrum" (PDF). Chemistry World: 62 66. Archived (PDF) from the original on 9 October 2022.

De Larrard, F. (1999), "Concrete mixture proportioning: A Scientific Approach," London.

Dhir, R. K., McCarthy, M. J., Zhou, S., and Tittle, P. A. J. (2004). Role of cement content and specifications for concrete durability: cement type influences. Structures and Buildings, Institution of Civil Engineers, U.K., 113-127.

Donza, H., Cabrera, O., & Irassar, E. (2002). Highstrength cocrete with different fine aggregate. Cement and Concrete Research, 32 (11), 17551761.

Federal Highway Administration. Archived (PDF) from the original on 9 October 2022 :Fifth Annual International Center for

Aggregates Research Symposium.

Frankham, W. (1890): Monthly reports by the inspector on materials received at Fort Cautley. New Zealand Defences (unpublished).

Kosmatka, S., Kerkhoff, B., and Panarese, W.C. (2002). Design and control of concrete mixtures, 14th Edition., Portland Cement Association, Skokie, IL, USA.

Lafrenz, J. (1997). Aggregate Grading Control for PCC Pavements:Improving Constructability of Concrete Pavements by Assuring Consistency of Mixes. Austin,

Larrard, F., & Belloc, A. (1997). Influence of aggregate on the compressive strength of normal and high-strength concrete. ACI Material Journal, 417-426.

Marsh, C.f., (1905), “Reinforced concrete design”. Archibald Constable and Company, London.

McNally, G. (1998). Soil and Rock Construction Materials (Firsted.). NewYork: Routledge.

Mehta, K. P., and Monteiro, P. J. M., (1993). “Concrete structure, properties, and materials”. Second Edition., Prentice Hall incorporated, New Jersey.

Mindess, S., Young, J, F., and Darwin, D. (2003). “Concrete”. 2nd Edition, Prentice-Hall Incoporated., Englewood Cliffs, New Jersey.

Mitchell, C.F. (1909). “Components, services and finishes”. Mitchell’s advanced building construction. Revised by Denzil Nield. B.T. Batsford, London. Pp. 12-28.

Mohammed, M. S ., Salim, Z ., & Said, B. (2010). Effect of content and particle size distribution of coarse aggregate on the compressive strength of concrete. Construction and Building Materials , 24, 505-512.

Montgomery, D.c., Peck, EA., and Vining, G.G., (2001) Introduction to linear Regression, 3rd Edition. John Wiley and Sons, Inc. New York.

Neville, A ., & Brooks, J. (2010). Concrete Technology (2nd ed.). London: Prentice Hall.

Neville, A. M. (1995), Properties of Concrete, 4th Edition. Addisson Wesley Longman, England.

Ozturan, T., and Cecen, C., (1997), Effect of Coarse Aggregate Type on Mechanical Properties of Concretes with Different Strength, Cement and Concrete Research, Vol 27, Issue 2, Pp 165-170

Popovics, S. (1994). "The Slump Test is useless" Concrete International, Volume 16, Number.9. Pp. 30-33.

Ruiz, W. (1966). Effect of Volume of Aggregate on the Elastic and Inelastic Properties of Concrete. Cornell: Cornell University.

Stensatter, G. A. (1963). Influence of aggregate particle shape upon concrete strength. Bozeman, Montana: Montana State College.

Woode, A ., Amoah, D. K ., Aguba, I. A ., & Ballow, P. (2015). The Effect of Maximum Coarse Aggregate Size on the Compressive Strength of Concrete Produced in Ghana Civil and Environmental Research , 7, 7.

Zhou, F ., Barr, B ., & Lydon, F. (1995). Effect of coarse aggregate on the elastic modulus and compressive strength of high performance concrete. Cement and Concrete Research, 177186

Zhou, F., Barr, B., & Lydon, F. (1995), Fracture Properties of High Strength Concrete with varying Silica Fume content and aggregates. Cement and Concrete Research, 543-552.