A STUDY ON COMPRESSIVE STRENGTH CHARACTERISTICS OF CONCRETE ON DIFFERENT DATES

BY

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SUBMITTED TO

THE DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B.ENG) IN

CIVIL ENGINEERING

NNAMDI AZIKIWE UNIVERSITY

AWKA

FEBRUARY 2022

CERTIFICATION

This is to certify that this research study carried out by Ezenweke Anastesia Chinenye (Registration Number 2016224044) from the department of civil Engineering Nnamdi Azikiwe University, Awka, Anambra State.

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APPROVALS PAGE

This project has been read and approved by the undersigned as meeting the requirement of the Department of Civil Engineering, Faculty of Engineering, Nnamdi Azikiwe University, Awka for Award of B.ENG in Civil Engineering.

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DEDICATION

This project is most importantly dedicated to Almighty God, who through his ceaseless love, protection and mercies brought me this far in the cause of my academic pursuit.

ACKNOWLEDGEMENT

First of all and most importantly, I give thanks to almighty God for his favor, grace, guidance, strength and mercies upon by life and his abundant wisdom to push through my academic sessions.

My unending gratitude goes to my supervisor, Engr. I. Omaliko for his patience, guidance, encouragement and wonderful aid he gave me in getting this project research done. Thank you sir

I thank profusely all my lecturers in the department of civil engineering for their guidance, support, endurance and love

I owe a deep sense of gratitude to also Engr. B. Joseph of M.I.O. Construction Company for his love, care and guidance towards the success of my research work.

My heartfelt appreciation and deepest sense of gratitude goes to my family, my parents Mr and Mrs Arinze Ezenweke for their love, prayers, caring and sacrifices for educating and preparing me for my future. I am very much thankful to my siblings for their love, understanding, prayers, and continuing support to complete this research work.

I an extremely thankful to my friends Ruth, Vivian, Precious, Stanly and Anthony, this would have been a much difficult feast without you. Thank you all for your unwavering support and for reminding me to take breaks when I have been stressed out.

I thank profusely all my lecturers in the department of civil engineering for their guidance, support, endurance and love

ABSTRACT

This research investigation was based on the variation in the compressive strength of concrete cast on different dates. Thus, this experiment showcased the investigative results of concrete cast on different dates using different size of aggregates. This test was cured and crushed with different number of days, 7, 14, 21 and 28 days to test its compressive strength. The test was conducted under constant environmental conditions with the mix ratio 1.2.4 of cement, fine aggregate and coarse aggregate. Hand compaction was used and curing was by immersion i.e. deeping the cubes inside the curing tank and crushed after 7, 14, 21, and 28 days respectively. The variation in strength on curing age from the graph shows that there was rapid increase of strength gain for the first 7 days after which it reduced from the 14th day and then increases from 21 to 28 days. The result of analysis carried out from the crushing strength showed that concrete strength increases with curing age of 7 to 28 days. It also show that the strength of concrete increases progressively with the age of curing and there is rapid strength gain in the first 7 days of curing and concrete gains its maximum strength at 28 days of curing. In this research, different sizes of coarse aggregates ranging from 10mm, 16mm and 25mm were used to cast Concrete. Compressive strength test and slump consisting for different sizes were measured. The result shows that the compressive strength of concrete made with 16mm at 28days of curing period was much higher followed by 25mm and 10mm. The factors affecting the compressive strength of concrete were also discussed, while aggregate parts were buttressed extensively. Also, particle size distribution analysis was conducted in the course of this project for proper grading and classification. The entire test was done with the British standard (BS) specifications.

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CAPTER ONE

INTRODUCTION

Concrete is a composite material produced by mixing homogeneously selected proportions of water, cement, aggregates (fine and coarse). Concrete is said to be the second substance most used in the world after water, and is one of the most frequently used building materials. Approximately, three quarter of the volume of concrete are occupied by aggregates (Gumede and Franklin, 2004.The most dominant construction material is Concrete and the most collapse structure is Concrete structure. A number of researches (Ayininuola and Olalusi,2011) have identified the use of substandard materials, particularly Concrete as the leading cause of building collapse in Nigeria. Concrete failure still occurs despite adequate design and mix ratio. This advocates the existence of a breach in requirement for production of quality Concrete. Previous works confirm the use of inferior concrete aggregates materials as among the causative elements of structural Concrete failure in building. Gollu et al.(2016)mentioned unsuitable materials, unsound aggregate, reactive aggregate, and contaminated aggregate as part of the sources of concrete failure in buildings.Akineleyeand Tijani(2017) stated that the use of low quality aggregates also affect the performance of asphalt Concrete in southwest Nigeria. Concrete will only become a quality material for construction when their constituents are properly sourced. The quality of aggregate can vary significantly due to the geographical location and environmental condition (Ajagbe et al., 2018).

Fowler and Quiroga (2003) reported that aggregates are expected to have important effects on the properties of concrete since they occupy 70-80% of it. Concrete aggregates and paste are the major factors that affect the strength of concrete (shetty, 2005), the properties of aggregate greatly affect the durability and structural performance of concrete as aggregate with undesirable propertiescannot produce strong Concrete (Neville,2001).According to Mehta and Menterio (2001), the aggregates exercise a significant influence on strength, dimensional stability, and durability of concrete. Ajagbeand Tijani (2016) stated the assessment of concrete aggregate is vital to overcome the problem of structural collapse due to Concrete failure in a certain environment. De Larrard (1999) and Dewar (1999) agreed that the aggregate source has an impact on concrete strength. Concrete strength is govern by aggregate size, type, and source (Hassan, 2014: Aginam et al., 2013; Jimoh and Awe, 2017; Abdullahi, 2012).

Comprehensive strength is the most significant mechanical property of concrete. It is obtained by measuring Concrete specimen after curing for days. Some of the factors that influence the Concrete strength include aggregate quality, cement strength, water content and water/ cement ratio (Noorzaei ET el., 2007).

Concrete should be strong enough, when it has harden, to resist the various stresses which it will be subjected to. Hardened Concrete has a number of properties, including:

1. Mechanical strength, in particular compressive strength.
2. Durability
3. Porosity and density
4. Thermal and acoustic insulation properties.
5. Impact resistance.

When freshly mixed, it must be of such mixed it must be of such a consistency that it can readily be handled with segregation and easily compacted in the formwork leading to the homogeneity of the finished work. The strength of concrete is governed by several factors such as ratio of cement to water, ratio of cement to aggregates, maximum size of aggregates, grading, surface texture, shape, strength and stiffness of aggregate particles. Fresh concrete has many applications and can be cast into circle, rectangle, squares and more. It can also be used for staircases, columns, doors, beams, lintels and other familiar structures.

BACKGROUND

The role of aggregate in concrete is central to this report. While the topic has been under study for many years, an understanding of the effect of coarse aggregate has become increasingly more important with the introduction of high strength concrete, since coarse aggregate plays a progressively more important role in concrete behavior as strength increases.

In normal strength concrete, failure in compression almost exclusively involves deboning of cement paste from the aggregate particle at what, for the purpose of this report, will be called matrix aggregate interface. In contrast, in high strength concrete, the aggregate particle as well as the interface undergoes failure, clearly contributing to overall strength. As the strength of the cement paste constituent of concrete increases, there is greater compatibility of stiffness and strength between the normally stiffer and stronger coarse aggregate and the surrounding mortar. Thus, micro cracks tends to propagate through the aggregate particle since, not only is the matrix aggregate bond stronger than in concrete of lower strength , but the stresses due to a mismatch in elastic properties are decreased. Thus, aggregate strength becomes an important factor in high strength concrete.

This report describes work that is aimed at improving the understanding of the role of aggregate in concrete. The variables considered are aggregate type, aggregate size and aggregate contenting normal and high strength concrete. Compression, flexural, and fracture test are used to better understand the effects aggregates have in concrete

1.1 THE BENEFITS OF CONCRETE

There is numerous positive aspect of concrete:

1. It is relatively cheap material and has a relatively long life with few maintenance requirements.
2. It is strong in compression.
3. Before it hardens, it is a very pliable substance that can easily be shaped.
4. It is not combustible.

1.2 THE LIMITATIONS OF CONCRETE INCLUDE:

1. Relatively low tensile strength when compared to other building materials.
2. Low Durability
3. Low strength to weight ratio.
4. It is susceptible to cracking

1.3 THE TYPES OF CONCRETE

Concrete is made in different grades, including normal, standard and high- strength grades. This grades indicate how strong the Concrete is and how it will be used in construction. They are three grades or classes of cement in Nigeria, namely grades 32.5,45.5,and 52.5.These grades corresponds to the minimum 28 day compressive strength of cement mortar after curing(COREN,2017). It is important to note that the most common type of cement in Nigeria is the Portland limestone cement (PLC)and not Ordinary Portland cement (OPC). The cement available in the open Market of Nigeria is the Portland limestone cement designated as CEM II in NIS 444-1(2003). PLC is a modified OPC which is produced by adding 6-35% of limestone to OPC. It has a lower clinker content rage of 65-94% compared with OPC's range of 95-100 (Joeland and Mbapuun, 2016). It has lower carbon footprint than the OPC and is deemed more environmental friendly. The types of concrete include:

1. Normal strength Concrete
2. Plain or ordinary Concrete
3. Reinforced concrete
4. Pre-stressed Concrete
5. Lightweight Concrete
6. High density Concrete
7. Air-Entrained Concrete
8. Ready-mixed Concrete
9. Volumetric Concrete

10. Decorative concrete
11. Rapid set Concrete
12. Smart Concrete
13. Previous Concrete
14. Pumped Concrete
15. Limecrete
16. Glass Concrete
17. Asphalt Concrete
18. Shortcrete Concrete.

1.4 AIMS AND OBJECTIVES

The aim of this project is to investigate the compressive strength of concrete casted on different dates.

The objectives of this research are as follows:

1. To gather an abundance of pertinent information through an in-depth review of previous studies and pinpoint the areas that need to be addressed.
2. To carry out a sieve analysis of the fine and coarse aggregate.
3. To design the mix proportions.
4. To determine the workability of the fresh concrete.
5. Curing of all the concrete specimens for 7, 14, 21 and 28 (days).
6. To determine the compressive strength of the hardened concrete.

1.5 Scope of this Report

The purpose of this research work is to compare the compressive strength of concrete cast on different dates and also to compare the strength exhibited by the concrete cubes after different dates of curing. Because of the nature of this project, the investigations conducted were limited to particle size distribution, slump test and compressive strength test for 7days, 14 days, 21days and 28days of curing. This test provides an idea about the characteristics of concrete. By this single test one judge that whether concreting has been done properly. The mould size for the practical used is 150mm by 150mm and the water cement ratio used was 0.5 liter and the mix ratio is 1:2:4.

1.6 SIGNIFICANCE OF STUDY

Concrete being the major consumable material after water makes it quite inquisitive in its nature. The compressive strength of concrete is the strength of hardened concrete measured by the compression test to determine the concrete ability to resist loads which tends to compress it where as other stresses such as axial stresses are catered by reinforcements and other means. The significant/ important of conducting this test is to have an idea about the characteristics of concrete. By this single test one judges whether concrete has been done properly or not. The compressive strength of concrete depends on different factors such as water cement ratio, its constituents, cement strength, air entrainment, mix proportion, curing method, temperature effect quality of concrete material and quality control during the production of concrete. The aim of this project is to determine the strength of a concrete cube cast on different dates, to determine its strength after 28days curing period and also know the correct mix proportion to use for casting of concrete.

CHAPTER TWO

2.0 LITERATURE REVIEW

INTRODUCTION

In building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements. Various types of cements are used for concrete works which have different properties and applications. Some of the type of cement are Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement e.t.c. Materials are mixed in specific proportions to obtain the required strength. Strength of mix is specified as M5, M10, M15, M20, M25 andM30. Where M signifies Mix and 5, 10, 15 etc. as their strength in KN/m2.Water cement ratio plays an important role which influences various properties such as workability, strength and durability.

Adequate water cement ratio is required for production of workable concrete. When water is mixed with materials, cement reacts with water and hydration reaction starts. This reaction helps ingredients to form a hard matrix that binds the materials together into a durable stone-like material. Concrete can be casted in any shape. Since it is a plastic material in fresh state, various shapes and sizes of forms or formworks are used to provide different shapes such as rectangular, circular etc. Various structural members such as beams, slabs, footings, columns and lintels are constructed with concrete.(ACI 318 Building code requirements for structural concrete).

There are different types of admixtures which are used to provide certain properties. Admixtures or additives such as pozzolans or superplasticizers are included in the mixture to improve the physical properties of the wet mix or the finished material. Various types of concrete are manufactured these days for construction of buildings and structures. These have special properties and features which improve quality of construction as per requirement.

2.1 COMPONENTS OF CONCRETE

Components of concrete are cement, sand, aggregates and water. Mixture of Portland cement and water is called as paste. So, concrete can be called as a mixture of paste, sand and aggregates. Sometimes rocks are used instead of aggregates. The cement paste coat the surface of the fine and coarse aggregates when mixed thoroughly and binds them. Soon after mixing the components, hydration reaction starts which provides strength and a rock solid concrete is obtained. Grade of concrete denotes its strength required for construction.

Based on various lab tests, grade of concrete is presented in Mix Proportions. For example, for M30 grade, the mix proportion can be 1:1:2, where 1 is the ratio of cement, 1 is the ratio of sand and 2 is the ratio of coarse aggregate based on volume or weight of materials. The strength is measured with concrete cube or cylinders by civil engineers at construction site. Cube or cylinders are made during casting of structural member and after hardening it is cured for 28 days. Then compressive strength test is conducted to find the strength. Regular grades of concrete are M15, M20, and M25 etc. For plain cement concrete works, generally M15 is used. For reinforced concrete construction minimum M20 grade of concrete are used.

Concrete is manufactured or mixed in proportions with respect to cement quantity. There are two types of concrete mixes, i.e. nominal mix and design mix. Nominal mix is used for normal construction works such as small residential buildings. Most popular nominal mix are in the proportion of 1:2:4.Design mixed concrete are those for which mix proportions are finalized based on various lab tests on cylinder or cube for its compressive strength. This process is also called as mix design. These tests are conducted to find suitable mix based on locally available material to obtain strength required as per structural design. A design mixed offers economy on use of ingredients. Once suitable mix proportions are known, and then its ingredients are mixed in the ratio as selected. Two methods are used for mixing, i.e. Hand mixing or Machine Mixing. Based on quantity and quality required, the suitable method of mixing is selected. In the hand mixing, each ingredient is placed on a flat surface and water is added and mixed with hand tools. In machine mixing, different types of machines are used.

In this case, the ingredients are added in required quantity to mix and produce fresh concrete. Once it is mixed adequately it is transported to casting location and poured in formworks. Various types of formworks are available which as selected based on usage. Poured concrete is allowed to set in formworks for specified time based on type of structural member to gain sufficient strength. After removal of formwork, curing is done by various methods to make up the moisture loss due to evaporation. Hydration reaction requires moisture which is responsible for setting and strength gain. So, curing is generally continued for minimum 7 days after removal of formwork.

2.2 TYPES OF CONCRETE CONSTRUCTION

Concrete is generally used in two types of construction, i.e. plain concrete construction and reinforced concrete construction. In PCC, it is poured and casted without use of any reinforcement. This is used when the structural member is subjected only to the compressive forces and not bending. When a structural member is subjected to bending, reinforcements are required to withstand tension forces structural member as it is very weak in tension compared to compression. Generally, strength of concrete in tension is only 10% of its strength in compression. It is used as a construction material for almost all types of structures such as residential concrete buildings, industrial structures, dams, roads, tunnels, multi storey buildings, skyscrapers, bridges, sidewalks and superhighways etc. Example of famous and large structures made with concrete are Hoover Dam, Panama Canal and Roman Pantheon. It is the largest human made building materials used for construction.

2.2.1Steps of Concrete Construction

1. Selecting quantities of materials for selected mix proportion
2. Mixing
3. Checking of workability
4. Transportation
5. Pouring in formwork for casting
6. Vibrating for proper compaction
7. Removal of formwork after suitable time
8. Curing member with suitable methods and required time.

The variations on the compressive strength of concretes made with respect to tropical climate as patterning to Nigeria in particular has not been fully worked on by many researchers. As a result, it became difficult to lay hands on such information.

Originally, aggregates according to Neville, were viewed as an inert material dispersed through-out the cement paste, largely for economic reasons. He went further to state the fact that aggregates are not truly inert and its physical properties influence performance of concrete. The strength requirement is generally specified in terms of characteristic strength (BS 8110: Part 1) coupled with a requirement that the probability of the strength falling below this shall not exceed certain value. Neville stated that the shape of aggregate, its surface texture and cleanliness influence the bond strength of concrete.

He also stressed that in experimental concrete, entirely smooth coarse aggregates led to lower compressive strength, typically by 10% than when roughened. Also on the effect of sizes, Aggregates with maximum size of coarse aggregates has lower compressive strength. Also, according to the University of Technology Malaysia, on the effect of aggregate shape, surface texture and cleanliness; "a smooth rounded aggregate will result in a weaker bond between the aggregates and the matrix than an irregular aggregate with rough surface texture".

Explaining further, "a fine coating of impurities such as silt and clay on aggregate surface hinders the development of a good bond. The aggregate size can also affect strength. For a given matrix proportion, the concrete strength decreases as the maximum size of aggregates increases. Concrete of a given strength can be produced with well graded aggregates. I. This just mentioned case, segregation does not occur". According to national ready mixed concrete association, they carried out a research work on coarse aggregate and in their conclusion, at a given water ratio, within the range employed in most structural concrete, smaller maximum size of aggregate will tend to produced higher concrete strengths than larger ones. Secondly, the larger sizes will require less mixing water and hence for a given cement factor, will produce of lower water ratio than the smaller sizes.

Bloem and Gaynor (1963) jointly studied the effects of aggregate properties on the strength of concrete and they reported' that, tests were made with 546 combinations of fine and coarse aggregate to study the effect of shape, surface texture, fine coatings, strength, and maximum size other properties on water requirement and strength of concrete. The results showed that at equal water-cement ratio, irregular shaped smaller sized aggregates without coatings, and those of higher concrete strength. Also according to the same report, depending on circumstances such as richness of concrete mix, individual properties of the particular aggregates and the magnitude of the size difference, and increase or decrease in concrete strength at a fixed cement content.

Stantom and Bloem(1960) reported that at different water-cement ratio, strength levels prevail for the maximum sizes. Without exception, the level increased with reduction in maximum size. This implies that at same water-cement ratio, there is always a reduction of strength of concrete as the maximum size of aggregate increases. The presence of clay or crush dust, or silt or rather generalizing; presence of over coatings of aggregates is not surprising because it interferes with the bond between the aggregates and cement paste. Another fine material which may be present on a coating on aggregates is silt. Silt possesses some tendencies similar to that of clay and it may undergo like clay, considerable shrinkage and expansion when exposed to changes in moisture content. Clay, silt, crush and dust should not be in excess on aggregates so as not increase the amount of water necessary to wet all particles in the mix.

The IPRF (Innovative Pavement Research Foundation) report on the effect of micro fine coatings hinders the development of a good bond thereby reduces the compressive strength of concrete and at the same time increases the shrinkage of the concrete. Aggregates are also to be seen as anti-crackers in concrete because of its great function in bonding. They can be as the skeleton of concrete. Consequently, an excess amount of organic materials in or on the aggregates prevents cement paste from forming and adequate bond with aggregates particles. According to an online article in press, the effect of coarse aggregate size on concrete under compression shows that the concrete strength slightly increases when at low confinement. At high confinement, the coarse aggregates size has a slight influence on concrete deviatory behavior and a significant influence on concrete strain limit state.

In conclusion, the higher the coarse aggregates size, the lower is the mean stress level corresponding to concrete strain limit state. Cement paste volume also has effect on concrete behavior. Otherwise decreasing cement paste volume increases concrete deformation capacity. Since this work deals mostly with the determination of variations that exists on compressive strength of concrete casted on different days, it then becomes necessary to analyze some factors which generally affect the strength of concrete as well as some properties of concrete, and also the effects of size of coarse aggregates on concrete.

2.2.3 LIMITATIONS OF CONCRETE

1. Concrete is quasi-brittle
2. Concrete has low toughness
3. Concrete has low specific strength
4. Formwork is required
5. Long curing time
6. Demands strict quality control
7. Relatively low tensile strength when compared to other building materials
8. Low Duct ability
9. Low strength to weight ratio
10. It is susceptible to cracking

2.3 CLASSIFICATION OF CONCRETE

Based on unit weight:

1. Ultra-light concrete $< 1,200$ kg/m^3
2. Lightweight concrete 1200- 1,800 kg/m^3
3. Normal-weight concrete 2,400 kg/m^3
4. Heavyweight concrete $> 3,200$ kg/m^3

Based on strength:

1. Low-strength concrete < 20 MPa compressive strength
2. Moderate-strength concrete 20 -50 MPa compressive strength
3. High-strength concrete 50 - 200 MPa compressive strength
4. Ultra high-strength concrete > 200 MPa compressive strength

2.4 PROPERTIES OF CONCRETE

To obtain a good quality concrete, its properties in both fresh and hardened states play important rules.

Properties in Fresh State Include

1. Workability
2. Segregation
3. Bleeding
4. Hardness

The properties in hardened state include

1. Strength
2. Durability
3. Impermeability
4. Dimensional change

2.5 Workability of Concrete

Workability of concrete is a broad and subjective term describing how easily freshly mixed Concrete can be mixed, placed, consolidated and finished with minimal loss of homogeneity .ASTMC 125-93. Workability is a property that directly to impact strength, quality, appearance, and even the cost of labor for placement and finishing operation.

Types of workability of concrete

According to the American Concrete institute (ACI) standard 116R-90(ACI 1990), Workability of concrete can be classified into three types

1. **Unworkable Concrete:** An unworkable Concrete also known as harsh Concrete, is a concrete with a very little amount of water. The hand mixing of such Concrete Is difficult, such type of concrete had high segregation of aggregates and it is very difficult to maintain the homogeneity of Concrete mix.
2. **Medium workable Concrete:** Medium workable Concrete is used in most of the construction works. This Concrete is relatively easy to mix, transport, place and compact without much segregation and loss of homogeneity.
3. **Highly workable Concrete:** This type of concrete is very easy to mix, transport, place and compact. It is used where effective compaction of concrete is not possible. The problem is that they are high chances of segregation and loss of homogeneity in highly workable Concrete.

The desirable Workability depends on two factors which are the section sizes, amount and spacing of reinforcement and the method of compaction.

2.6 Strength of Concrete

The strength of concrete is the most important property for us. It depends on density ratio or compaction and compaction depend on sufficient Workability BSI (1983), part 108. The different types of concrete strength are;

1. **Compressive strength:** It is widely accepted measure to access the performance of a given concrete mixture. It accurately tells you whether or not a particular mix is suitable to meet the requirements of a specific project.

2. **Tensile strength of concrete:** The tensile strength of concrete is its capacity to resist cracking or breaking under tension. Although Concrete is rarely loaded under pure pressure in a structure, determining the tensile strength is necessary to understand the extent of the possible damage. Breaking and cracking arise when tensile forces surpass the tensile strength.
3. **Flexural strength of concrete:** Flexural strength establishes the ability of concrete to withstand bending. It is an indirect measure of tensile strength. The Flexural strength of concrete is usually determined by testing a simple beam where the concentrated load is applied at each of the third points. The numbers are expressed in a modulus of rupture (MR) in psi.

2.6.1 Factors Affecting the Strength of Concrete

The strength of concrete is usually affected by many factors, in this project work; such factors are discussed with particular reference to the compressive strength. The factors include:

Cement

The influence of cement on concrete strength, for a given mix proportion is determined by its fineness and chemical composition through the process of hydration. Generally, cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a compact whole. For construction purposes, which are the case in this project work, the term cement is restricted to the bonding material used with stones, sand, bricks and building blocks. The gain in strength as the fineness of its cement particles increases cannot be underestimated. The gain in strength is most marked at early ages and after 28days the relative gain in strength is much reduced.

The role of the chemical composition of cement in the development of concrete strength can always be appreciated. It is apparent that cement which contain a high percentage of tricalcium silicate (Ca3S) gain much more strength rapidly than those rich in dicalcium silicate (Ca2S). The sulphate resistance of concrete can be improved by the use of sulphate resisting cement which has low tricalcium Aluminates content.

However, there is a tendency for concretes made with low- heat cements eventually to develop slightly higher strengths. This is possible due to the formation of a better quality gel structure in the course of hydration. Because we are in the tropics, low heat cements best advisable to use in concreting. This is because the heat evolved during the cement hydration process needs to be reduced. The use of low heat cement can minimize this effect. However, most (OPC) ordinary Portland cements we use are (LH) i.e. Low heat cement. The specification for Portland cement is the BS 12:1991 of the British standard.

Water

A concrete mix containing the minimum amount of water required complete hydration of its cement, if it could be fully compacted, would develop the maximum attainable strength at any given age. Water plays a critical role, particularly the amount used. The strength of concrete increases when less volume of water is used to make it. The hydration reaction itself consumes a specific amount of water. A water-cement ratio of approximately 0.25 (by weight) is required for full hydration of the cement but with this water content normal concrete mix would be extremely dry and virtually impossible to compact. Concrete is actually mixed with more water than is needed for the hydration reaction.

This extra water is added to give concrete sufficient workability. Flowing concrete is desired to achieve proper filling and composition of the forms. The water not consumed in the hydration reaction will remain in the micro- structure pore space. Adequate compaction will then be introduced to reduce the pore space. A partially compacted mix will contain a lot of voids and subsequently or rather consequently the concrete strength will drop. On the other hand, while placing and compacting, water in its excess for full hydration would consequently produce some porous structure resulting from loss of excess water. Consequently, in practice if the ratio of water to cement increases the strength of that particularly concrete decreases. (BS EN 1008:2002 specifies-Mixing specification for water in concreting).

Aggregate

Aggregate is an important ingredient in concrete, which can be regarded as the skeleton of the concrete. The aggregate must have a minimum inherent strength requirement for structural concrete; the coarse aggregate must not be weaker than the concrete paste. Therefore, the bond between aggregate and cement paste is an important factor in the strength of concrete. The discussion of the aggregate as a factor that affects the strength of concrete will be based here on shape, surface texture, grading, size and strength of the aggregates. When a concrete mass is stressed, failure may originate within the aggregate, the matrix or at the aggregate-matrix interface; or any combination of these may occur.

The aggregate-matrix interface is an important factor determining concrete strength. Bond strength is influenced by the shape of the aggregate, its surface texture and cleanliness. Surface texture is generally only considered in relation to concrete flexural strengths, which are frequently found to reduce with increasing particle smoothness. However, inadequate surface texture can similarly adversely affect compressive strength in high strength concrete (say 50N/mm^2) when the bond with the cement matrix may not be sufficiently strong to enable the maximum strength of the concrete can be realized. Bonding mostly is due, in part, to the interlocking of aggregates and the paste owing to the roughness of the surface of the former.Coating of impurities, such as silt, clay and oil, on the aggregate surface hinders the development of a good bond. Aggregates with micro fine coatings hinder the development of a good bond thereby reducing the compressive strength of concrete and at the same time increasing the shrinkage of concrete.The size of aggregate also affects the strength of concrete. As the maximum size of aggregate is increased, the concrete strength decreases for a particular mix proportion. But invariably, in concrete works, the bigger or larger the aggregate size for a particular size of project the stronger the concrete required for the project.

The optimum maximum aggregate size varies with the richness of the mix, being smaller for the less rich mixes. Generally aggregate sizes lies between 10mm and 50mm in accordance with BS 812: part 1/1975.Good concrete can be made by using different types of aggregates (considering shapes) like rounded and irregular gravel and crushed rock which is mostly angular in shape. The grading of aggregates is a major factor, influencing the workability of a concrete mix. The grading should be such as to ensure that the voids between the larger aggregates are filled with smaller fractions and mortar so as to achieve maximum density and strength. The coarser and finer fractions of aggregates available at site can be suitably combined to obtain the desired standard grading. Aggregates which react with alkali content of cement adversely affect concrete strength.

Aggregates containing some forms of silica will react with alkali hydroxide in concrete to form a gel that swells as it absorbs water from the surrounding cement paste or the environment. These gels can swell and induce enough expansive pressure to damage concrete. Typical indicators of Alkali- silica Reaction (ASR) are random map cracking and, in advanced cases, closed joints and attendants spalled concrete. Cracking due to ASR usually appears in areas with a frequent supply of moisture, such as close to waterline in piers, near the ground behind retaining walls, near joints and free edges in pavements, or in piers or columns subject to wicking action. Petro graphic examination can conclusively identify ASR. ASR can be controlled using certain supplementary cementitious materials like silica fume, fly ash, and ground granulated blast-furnace slag in proper proportions. There also exists Alkali Carbonate Reactions (ACR), but is relatively rare.

It is common practice in Nigeria for construction to be carried out using locally founded aggregates of different sizes i.e. 8mm, 12mm and 14mm. This project engulfs the attainment of the functionality of locally found coarse aggregates of different sizes casted on different dates. The core functions which will aid this work are strength and economy. The specified standard and requirements available in recent times are based on materials which are from different sources and bearing in the fact that no two materials which are from different sources behave like, it is mostly likely they share the same properties but differs.

2.6.2 Classification of Aggregates

1. **Artificial aggregates:** They are manufactured industrial products. They are generally lighter than ordinary aggregates. The uses of these artificial aggregates arise not just from its light weight properties but because in many countries, there is a shortage of naturally occurring aggregates.

2. **Natural aggregates:** They are naturally occurring i.e. they are fond naturally. Distinction can be between aggregates reduced by natural agents to its present size and crushed aggregates obtained by deliberate rock fragmentation.

Fine aggregates either occur naturally in deposit distribution to some privileged locations over the earth surface or could be delivered by the reduction of some larger gravel to smaller sizes in quarry plants. Locally found fine aggregates are:

1. **River sand:** Sand deposits in river beds obtained by dredging or by locally divers scooping from the river beds up to the collection boats. River sand in Awka locality is often gotten from Amansea River. River sand is used in making concrete works, sandcrete and concrete blocks.
2. **Fine sand:** This is often used in rendering or plastering and mortar making. When these aggregates pass through sieve, they are usually of 0.06 - 0.6mm.
3. **Laterites:** This is used as filling sand or backfill for foundations and road basement

COARSE AGGREGATE

Coarse aggregates are irregular broken stone or naturally occurring gravel used in construction. The aggregate which will get retained on a 4.75mm sieve or the aggregate which have size more than 4.75mm are known as Coarse aggregate. They are commonly obtained by crushing the naturally occurring rocks. Aggregates are mainly classified into two types which are fine aggregates and coarse aggregates. The aggregates which are used in the construction must be durable, hard and strong, should not be soft and porous, must be free from the dust and organic materials and should be chemically inert. Aggregates are use in construction for even distribution of load and to increase the volume of concrete. Coarse aggregates are classified based on the nature or source of formation, according to size and according to shape.

Naturally occurring aggregates are obtained from the stone quarries and the stone crushers. Natural aggregate materials originate from bedrock. Artificially manufactured aggregates are gotten from the broken brisk or blast furnace slag. The air cooled slag is also used as a coarse aggregate. Coarse aggregate can come in different shapes which include rounded aggregates, angular aggregates, flaky aggregates and irregular aggregates. The properties of the coarse aggregate include size, shape, surface texture, water absorption, soundness, specific gravity and bulk modulus.

2.7 Water/Cement Ratio

The water-cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix. (Abrams, (1918) A lower ratio leads to higher strength and durability but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizer or super plasticizer. Often, the ratio refers to the ratio of water to cementitious materials, W/cm. Cementitious materials include cement and supplementary cementitious materials such as fly ash, ground granulated blast furnace slag, silica fume, rice husk ash and natural pozzolans (Duff, 1997).

Coarse and fine aggregates ratio

The maximal fine to coarse aggregate ratio described in ACI544.3R-2008is 0.6. Coarse and fine aggregate comprises almost 75%of total concrete volume, therefore, balancing the usage of fine aggregate and coarse aggregate plays vital role in determining the performance and quality of the concrete.

Aggregate/ cement ratio

Aggregate cement ratio is the ratio of weight of aggregate to the weight of cement. When the weight of cement is less, i.e. aggregate cement ratio is more, and then there will be very less cement paste to coat aggregate surfaces and fill the voids, thus mixing, placing and compacting of concrete will be higher than previous case.

2.7.1 Age of Concrete

Concrete increase in strength with age when moisture is available. This is initially greatest but progressively decreasing over time. The rate will be affected by cement type, cement content and internal concrete temperature. Moisture content of concrete also affect the age of concrete where by dried concrete immediately exhibits high strength due to the drying process but will not gain strength thereafter unless returned to and maintained in a moist condition.

2.7.2 Compaction of concrete

Compaction is the process which expels entrapped air from freshly placed Concrete. Compaction also allows the fresh Concrete to reach its potential design strength, density and low permeability. The different methods of Compaction of concrete are Manual compaction, Concrete compaction by pressure and jolting, concrete compaction by spinning and mechanical compaction by vibration. The four types of vibrators commonly used for Concrete compaction are

1. Internal vibrators
2. Form vibrators
3. Surface vibrators
4. Vibrating Tables

2.8 Curing of Concrete

Curing of concrete is a method by which the concrete is protected against loss of moisture required for hydration and kept within the recommended temperature range. (Agbede and Manasseh, 2008; Wazin, et al, 2011).Generally speaking, the longer concrete is kept under curing condition the greater its strength. The gain of strength during curing depends on a number of factors such as relative humidity, wind velocity and size of structural member or test specimen. The temperature at which concrete is cured is also an important factor in the development of its strength with time. It has been suggested that the strength of concrete can be related to product of age and curing temperature, commonly known as maturity. Curing will increase the strength and decrease the permeability of hardened Concrete. Curing also helps in mitigating thermal and plastic cracks

2.8.1 Shrinkage of Concrete

Shrinkage is the phenomenon which occurs in wet concrete when it loses moisture and invariably loses volume. It can be of two kinds: plastic shrinkage and drying shrinkage. Drying shrinkage in concrete is caused by loss of moisture in the paste. It is influenced by a variety of factors, which includes: environmental conditions (temperature and relative humidity), size of member (surface area to volume ratio), and etc. On the other hand plastic shrinkages result from surface evaporation due to environmental conditions such as humidity, wind speed or ambient temperature and restrained stresses.

In reinforced concrete structures, the restrains may be caused by the reinforcement bars or by supports. Shrinkages show as miniature cracks on the concrete surface. Concrete swells under moist conditions, but shrinks when there is change in volume by shrinkage or restrained stresses, as the case may be.

2.8.2 Creep in Concrete

Compressive strength is set up in concrete because of development of the menisci in the capillaries as drying of concrete progresses. These stresses transform to stresses we can see on the concrete surface as cracks. Creep of concrete develops gently and slowly. Creep of concrete results from the action of sustained stress which graduates into gradual increase to strain in time; it can be of the same magnitude as drying shrinkage. Creep does not include immediate elastic strains caused by loading or shrinkage or swelling caused by moisture changes. When a concrete structural element is dried under load that which occurs is one to two times as large as it would be under constant moisture conditions. Adding normal drying shrinkage to this and considering the fact that creep can be several times as large as the elastic strain on loading, it may be seen that these factors can cause considerable deflection and that they are of great importance in structural mechanics.

If a sustained load is removed, the strain decreases immediately by an amount equal to the elastic strain at given age; this is generally than the elastic strain on loading since the elastic modulus has increased in an intervening period. This instantaneous recovery is followed by a gradual decrease in strain, called creep recovery.There are numerous factors that affect creep in concrete as well as shrinkage. Relative humidity is first; when hydrated cement is completely dried, little or no creep occurs; for a given concrete the lower the relative humidity the higher the creep.

Second factor is the strength of concrete.

It has a considerable influence on creep within a wide range creep is inversely proportional to the strength of concrete at the time of load application. From this it follows that creep is closely related to water-cement ratio Modulus of elasticity of aggregates is the fourth factor that affect or influence creep in concrete. It is realized that concretes made with different aggregates exhibit creep in varying magnitudes. The fifth factor is age. Experiments have shown that creep for a very long time; detectable changes have been found after as long as 30years.The rate decreases continuously, however, and it generally assumed that creep tends to a limiting value.

The effects of creep on concrete cannot be underestimated .Creep hastens the approach of limiting strain at which failure takes place.

The influence of creep on the ultimate strength of a simply supported, reinforced concrete beam subjected to a sustained load is insignificant, but deflection increases considerably and in many cases may be a critical consideration in design. Another instance of the adverse effects of creep is its influence on the stability of the structure through increase in deformation and consequent of loads to other components. The loss of pre-stress concrete due to creep is well known and accounted for the failure of early attempts at pre-stressing. Only with the introduction of tensile steel did pre-stressing become a successful operation. The effects of creep may thus be harmful. On the whole, however, creep unlike shrinkage is beneficial in relieving stress concentrations and has to the success of concrete as a structural material.

2.8.3 Bleeding

In concrete, bleeding is a phenomenon in which free water in the mix rises up to the surface and forms a paste of cement on the surface known as laitance. Bleeding occurs in concrete when coarse aggregates tend to settle down and free water rises up to the surface. This upward movement of water while traversing from bottom to top makes continuous channels. These continuous bleeding channels are often responsible for permeability in structure. In the process of upward movement, the water gets accumulated below the aggregate and creates water void and reduces the bond between the aggregates and the paste.

Bleeding is a type of segregation, in which water comes of concrete. Segregation is the cause of bleeding in the concrete mix. Bleeding will be more frequent on the surface of concrete, when water to cement ratio is higher. The type of cement used, quality of fine aggregate also plays a key role in rate of bleeding. The effect of bleeding is that concrete losses its homogeneity and it is also responsible for causing permeability in concrete. Bleeding in concrete can be reduced by adding a minimum water content in the concrete, use chemical admixture to reduce demand to water for a required workability. Also the use of a proper design mix and fly ash or supplementary cementitious materials can reduce bleeding in concrete.

Influence of test conditions

The condition under which tests to determine the strength of concrete are carried out can have a considerable influence on the strength obtained and it is important that these effects are understood if test results are to be correctly interpreted.

Specimen shape and size

These are commonly used shapes for the compressive strength of concrete determination namely cubes cylinder and prism. Each shape gives different strength results. Also for a give shape, it varies in size. From the test conducted by Neville A. M.1963, based on specimen shape and size influence, it was found out that as size increases, the apparent strength increases. Also pertaining to their findings, height diameter ratio [for cylinder test] affects compressive strength. The specimens with lesser height diameter ratio came out with higher compressive strengths compared with the specimen with higher height diameter ratio. BS 1881 Part 116 specified the use of concrete cubes for determining compressive strength and quality control purposes, while

BS 1881 part 120 specifies cored cylindrical specimens for measuring the compressive strength in-situ and pre-cast members.

Method of loading

The compressive strength of concrete increases as the lateral pressure in concrete increases. The rate at which concrete is loaded affects the apparent strength of the Concrete. Generally, for static loading, the faster the loading rate the higher the indicated strength. High strength matured concrete cured in water are most sensitive to loading rate and particularly so for loading rates greater than 600N/mm^2/min.BS 1881: Part 4 requires concrete in compression test to be loaded at 15N/mm2/min while for flexural strength is 18N/mm2/min.

Placing and compacting of concrete

The operations of placing and of compacting of concrete are independent and are carried out almost simultaneously as they are most important for purpose of ensuring the requirements of strength, impermeability and durability of hardened concrete in the actual structure. The placing of concrete has to do with the direct introduction of concrete mix in the formwork. A good workable concrete with target class S3 (>100mm<150mm) is desirable for placing concrete in the formwork and around reinforcement, whether by skip or by pump.

Stiff mixes are difficult to place and compacting and most times consequently result in honey combing on concrete. In small scaled concrete works, concretes are normally placed with head pans and wheelbarrows. But in large scaled concrete works, concrete is often placed with skips from cranes and concrete pumps. Although some concrete are self-compacting, compacting is highly essential in concreting. It is used to eliminate the major air voids between aggregates in wet concrete. Compaction aids in achieving concrete with strong outcome. With adequate water-cement ratio administered in concreting, definitely a strong concrete will be result after compaction, devoid of honey combs, sand scouring, etc.

2.10 Crushing Strength

The crushing strength of concrete is influenced by a number of factors in addition to water cement-cement ratio and degree of compaction. The more important ones are:

1. **Cement type and quality**: The rate of strength gain and the ultimate strength may be affected. OPC cement concretes when prepared well and cured adequately can possess more compressive strength than RPC (Rapid Hardening Portland Cement).On the other hand, concretes whose qualities have been upgraded, that is, added admixtures like plasticizers or Retarders can bear more strength than ordinary concrete without admixture.
2. **Temperature**: Initial rate of hardening concrete is generally induced/ increased by an increase in Temperature but may lead to lower ultimate strength. At low temperature, the crushing strength may remain low for some time, particularly when cements of lower strength gain are used, but invariably may lead to higher ultimate strength.
3. **Efficiency of Curing**: A loss of strength of up to 40% may result from premature drying out. The method of curing concrete test cubes given in BS 1881: Part 3, 1983 should be strictly adhered to. Concrete properly cured is stronger and less susceptible to chemical attack, water tight and traffic wear.
4. **Type and Surface Texture of Aggregates**: This is considerable- to suggest that some aggregates produce concrete of greater compressive strength and tensile strength than others. This is as a result or consequence of type, surface texture, chemical properties, e.t.c.

5. **Moisture Content**: Concrete dried immediately exhibits high strength due to the drying process but will not gain strength thereafter unless returned to and maintained in a moist condition. Notably, dry concrete will exhibit a reduced strength when moistened thereafter.

2.11 Citations of Previous Works

Walker and Bloem (1960) studied the effect of coarse aggregates on the compressive strength of concrete. This work demonstrates that an increase in aggregate in a concrete mix increases the strength of the concrete. The study also shows that the flexural to compressive strength ratio remain at approximately 12 percent for concrete with compressive strength between 35 MPa (5100 psi) and 46 MPa (6700psi).

Ruiz (1966) in research on the effect of aggregate on the behaviour of concrete found out that the compressive strength of concrete increases along with an increase in coarse aggregate content. The increase is due to the reduction in the voids with the addition of aggregates.

Giaccio, Rocco, Violini, Zappitelli, and Zerbino (1992) studied the effect of coarse aggregate on the mechanical properties of high strength concrete.

Maher and Darwin (1976,1977) observed that the bond strength between the interfacial region and aggregate plays a less dominant role in the compressive strength of concrete than generally believed. Finite element model were used to evaluate the effect of matrix aggregate bond strength on the strength of concrete

2.12 Summary

The need for conducting the compressive test on concrete is to determine the strength of concrete cast on different dates and also to determine the necessary steps and from aggregate to avoid the use of substandard aggregate materials that might contribute to failure of structures and also to determine whether a given concrete mixture will meet the needs of a specific job. Compressive strength test also gives an idea of the overall strength of concrete and quality of a concrete produced.

CHAPTER THREE

3.0 MATERIALS AND METHOD

The objective of the preliminary test was to determine some physical properties of the concrete constituents and materials used in this work. These include the particle size distribution of fine

3.1 MATERIALS

The following concrete constituent materials and equipment were used during the process of carrying out this project. Since the investigation was on coarse aggregate, 3 different coarse aggregates were used while that of fine was one only.

Coarse aggregate

Aggregates used in this project (coarse) were made of three different sizes. The coarse aggregates were washed thoroughly with water to remove any impurity or dirt therein and then it was sun-dried to obtain saturated dry surface condition to ensure that the water-cement ratio is not affected. Some properties of coarse aggregates which affect the workability and bond between concrete matrixes are shape, texture, gradation and moisture content. The coarse aggregate size used was 10mm, 16mm and 25mm.

Fine aggregate

The fine aggregate used was dry river sand from Amansea River. The soil sample was thoroughly washed with clean water to remove any debris, organic matter and impurities present in the sand and then sun dried to obtain a dry surface condition and ensure that the water cement ratio is not in any way affected.

Cement

Ordinary Portland cement (Dangote Brand) was used for this work.

Water

The water for all the purpose in this work is fresh clean water gotten from the civil engineering laboratory water tank, which was clear, clean in appearance and without damaging amounts of oil, acid, salt, organic material and other substances that may impact the resistance of the concrete.

METHODOLOGY

3.3.1 Sieve Analysis

Sieve analysis is referred to as the simple operation of separating a sample of aggregate into fractions (groups), each consisting of particles of the same size. In practices, each fraction contains between specific limits, these being openings of standard test sieves. It is also shown graphically on particle size distribution curve for the purpose of obtaining the grade of the aggregate. The main aim is to determine the various sizes of particles present in aggregates.


Apparatus

In the analysis, the following apparatus were used:

1. B.S test sieves of different sizes complying with the requirements of B.S 410, full tolerance
2. A weighing balance
3. Metal brush
4. Stop watch
5. Plate

Procedure

1. The fine aggregate samples were collected in a suitable quantity. Note: the larger the particle size, the quantity required.

2. The aggregate were dried and kept free from moisture and was also protected from containing any lumps.

3. The sample is sieved through a 5mm sieve; the portion retained on the sieve was discarded while those passing through were used for the particle size analysis.

4. The sample gotten from the 5mm sieve is placed in the top sieve and the set of sieves is kept on a mechanical shaker and the machine is started.

5. The machine is allowed for 10 minutes of shaking for sufficient particles to pass.

6. The mass of the samples retained on each sieve and on pan is obtained to the nearest 0.1gm.

7. The mass of the retained aggregate is checked against the original mass.

8. A graph is plotted to ascertain the grade of samples.

3.4 PRODUCTION OF CONCRETE

Batching

Batching is the process measuring ingredients or materials to prepare concrete mix. Batching can be done of two methods, volume batching and weight batching. Batching should be done properly to get quality concrete mix. Batching by Weight is considered to be more accurate than volume batching hence; batching was done by weight for the Purpose of this work. As much as possible, there would always be variation in the proportion of voids in the aggregates; volume batching therefore is considered as not being very reliable and accurate for the test. Method of batching adopted in this work was based on the calculation of the necessary number of specimen to be cast for each of the coarse aggregate. The moulds used were of each of the dimensions and so their volume could be calculated.

3.4.1 Mix Design

The concrete mix design adopted for this research is as stated below; the design was adopted based on the availability of the material and also the aim of the experiment.

Density of concrete = 2400Kg/m^3

Volume of cube sample = 150mmx150mmx150mm =3375cm^3 =3375cm^3/100^3 =3.375x10-^{3}m^3

Density =mass/volume

Where mass =2400kg/ m^3 x0.003375 m^3 = 8.1Kg

Using mix ratio = 1: 2: 4 =1+2+4+0.45 = 7.45

W/C= W/1.16 =0.45 = W=1.16 x 0.45= 0.522kg =522ml.

Cement =10x 1.16Kg =11.6kg

Fine aggregate=10 x 2.3Kg =23kg

Coarse aggregate=10x 4.6Kg=46kg.

Concrete characteristic Strength, Fcu at 28 days = 30 MPa

3.4.2 Mixing of concrete

The process of mixing was performed on the floor of the concrete technology laboratory by hand using trowel. After weighing out the various quantities of materials, the cement and the fine aggregate were first mixed under dry condition until the mixture became thoroughly blended, then the coarse aggregate was introduced, mixed with the already mixed cement and sand until the mix becomes uniformly distributed throughout the batch. As the mixing process continued the quantity of water calculated for was carefully and gradually added. The mixing proceeded until a homogeneous concrete mix appears and the desired consistency emerged.

3.4.3 Casting of Concrete

The moulds used for the casting was 150mmx 50mmx150mm. Before the casting operation was carried out, the moulds were properly cleaned and inside oiled with used engine oil (as releasing agent) to ensure easy de-molding operation. The concrete in the mould were filled in three layers approximately 50mm thick with the Concrete (that is, about 50mm depth). Adequate compaction by hand was done using a standard steel tamping rod; each layer was compacted with at least 25 strokes per layer using the tamping rod before the cube mold is fully filled up with concrete and then compact completed. The trowel was used to give smooth finish on the surface after casting.


3.5 Workability of Concrete

Workability of concrete has never been precisely defined. Practical purpose it generally implies the case with which concrete mix can be handled from the mixer to its final compacted shape. The three main characteristics of the property are consistency, mobility and compatibility.

Consistency is a measure of wetness or fluidity .Mobility defines the ease with which a mix can flow into and completely fill the mould or formwork. Compatibility is the ease with which all trapped a given mix can be fully compacted to remove all air. Four tests are widely used for ensuring workability such as slump tests, compacting factor, and time and flow test. But for the purpose of this research, slump test was used.

3.5 Slump Test

Slump test is used for the measurement of a property of fresh concrete. The test is an empirical test that measures the Workability or flow of fresh concrete. ASTM C143 More specifically, it measures Consistency between batches. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions.

Apparatus

1. A truncated slump cone: height =300mm Tamping Rod
2. Measuring Tape

3. Trowel
4. Base plate
5. Brush

Procedure

A freshly mixed concrete with water-cement ratio of 0.5 was made. The following steps were undertaken to carry out the slump test:

1. The cone was placed on the flat form tray in a position such that the wider surface is on the form.
2. The cone was filled in 3 layers of equal height with trowel giving each layer 25 stokes or taps.
3. After leveling and smoothing the top of the concrete and clearing around the cone of any dropping, the cone was lifted upright with two hands.
4. After pulling the cone, it was placed close to the concrete without applying any vibration or jointing round plat form.
5. The sprit level was trace on top of the cone to span across the concrete.
6. The measuring tape was then place perpendicular to the straight edge and lowered to the top of the slump concrete.
7. The difference in height between the top of the cone and the top of the slumped concrete was then measured and recorded.

3.6 Curing of Concrete

After the casting, proper identification marks were given showing time interval and the type of coarse aggregate used. Then the concrete moulds were left in the laboratory for 24 hours. It was left uncovered because the relative humidity of the period was fairly high since it was done during the rainy season. The cube were demoulded after 24 hours and then transferred into the curing tank.

3.7 Compressive Strength Test

The compressive strength test was carried out using the compressive strength test machine as find in the test method BS 1881 part 116, 1983. An increasing compressive strength was introduced to the cube specimen until failure occurred to obtain the maximum compressive load. The specimen dimension was taken before testing. The testing was carried out for 7, 14, 21 and 28 days after curing.

$$\text{Compressive strength} = \frac{Compressive\ Load, P\ (KN)}{Surface\ Area, A\ (mm^2)} \qquad (1)$$

Procedure

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m.
3. Clean the bearing surface of the testing machine.
4. Place the smoothest side of the specimen in the machine in such a way that the loads shall be applied to the opposite sides of the cube.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the loads gradually without shock and continuously at the rate of 140Kg/cm/minute till the specimen fails.

Record the maximum load and note any unusual features in the type of the failure.

CHAPTER FOUR

4.0 RESULTS AND ANALYSIS OF ALL TESTS

SIEVE ANALYSIS (PARTICLE SIZE DISTRIBUTION OF FINE AGGREGATE)

TABLE 4.1

Weight of sample=500gms

Sieve size (m)	Weight retained (g)	% weight retained	Cumulative weight retained (%)	Cumulative weight passing (%)
4.75	4.63	0.926	0.926	99.070
2.00	8.82	1.764	2.690	97.310
1.80	16.23	3.226	5.916	94.084
0.85	20.30	4.060	9.976	90.024
0.60	49.74	9.948	19.924	80.076
0.45	91.81	18.362	38.286	61.714
0.30	154.01	30.802	69.088	30.912
0.15	142.84	28.568	97.656	2.344
0.075	10.30	2.060	99.716	0.284
Plate	1.42	0.284	100.00	1.000
Total	500			

PARTICLE SIZE DISTRIBUTION OF COARSE AGGREGATES

TABLE 4.2

Weight of test sample=1250gms

Sieve sizes (mm)	Weight retained (g)	% weight retained	Cumulative % passing	Cumulative % retained
54.40			100.00	
25.40	5.00	0.40	99.60	0.40
16.52	380.00	30.40	69.20	30.80
9.52	570.75	46.14	23.06	76.94
4.76	283.75	22.70	0.36	99.64
Plate		0.36	0.00	100.00
Total	1250			

SLUMP TEST RESULTS

Table 4.3

Mix size	Mix Ratio	Height of cone	Height of slump Concrete	Slump value
10mm	1:2:4	300mm	203mm	92mm
16mm	1:2:4	300mm	205mm	93mm
25mm	1:2:4	300mm	207mm	95mm

DETERMINATION OF THE COMPRESSIVE STRENGTH OF CONCRETE TEST RESULTS FOR COARSE AGGREGATE OF SIZE 25mm

Table 4.4

Specimen	Age of Curing (Days)	Area of Specimen (150mm by 150mm)	Weight of Specimen (kg)	Average Test load (KN)	Mean compressive strength (N/mm^2)
B11	7	150	8.4	582.5	17.43
C11	14	150	8.3	630.28	18.60
D11	21	150	8.4	690.35	20.99
E11	28	150	8.5	756.30	21.99

DETERMINATION OF THE COMPRESSIVE STRENGTH OF CONCRETE TEST RESULTS FOR COARSE AGGREGATE OF SIZE 16mm

Table 4.5

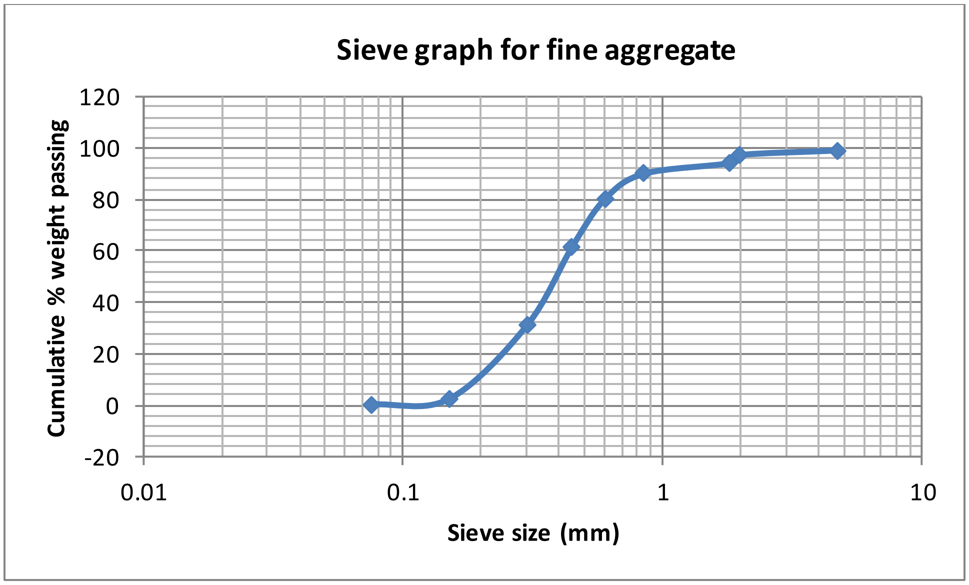
Specimen	Age of curing (Days)	Area of specimen (150mm by 150mm)	Weight of specimen (kg)	Average Test Load (KN)	Mean compressive strength (N/mm^2)
B11	7	150	8.4	642.67	19.62
C11	14	150	8.5	666.90	20.03
D11	21	150	8.4	774.85	23.67
E11	28	150	8.3	801.00	24.02

DETERMINATION OF THE COMPRESSIVE STRENGTH OF CONCRETE TEST RESULTS FOR COARSE AGGREGATE OF SIZE 10mm

Table 4.6

Specimen	Age of curing (days)	Area of specimen (150mm by 150mm)	Weight of specimen (kg)	Average test load(KN)	Mean compressive strength (N/mm^2)
B11	7	150	8.8	320.40	14.02
C11	14	150	8.7	356.76	15.20
D11	21	150	8.7	380.00	16.78
E11	28	150	8.9	426.06	18.05

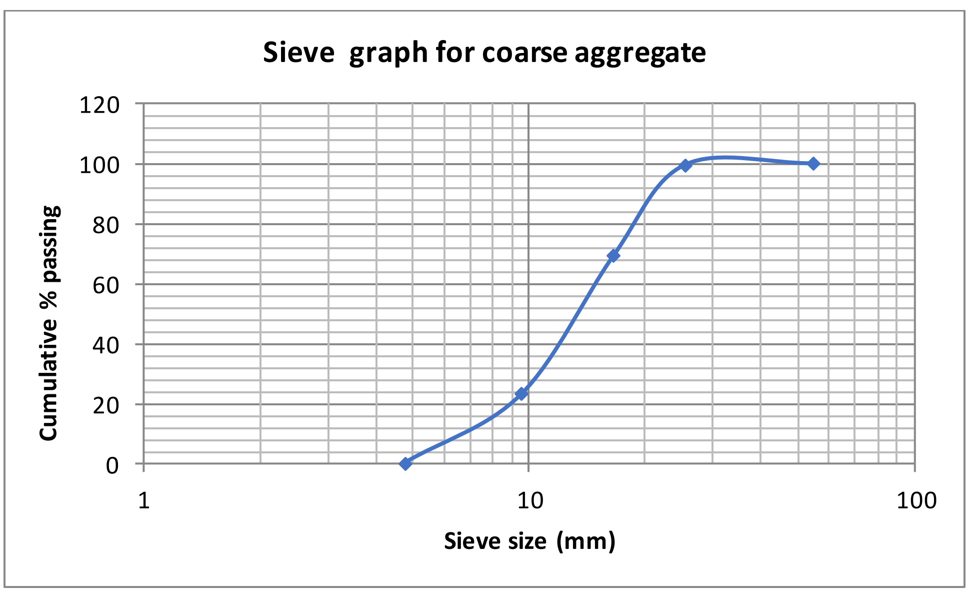
Figure 1 fine aggregate sieve analysis graph



Aggregate Analysis (Fine Aggregate)

The result of sieve analysis from figure 4.1 clearly show the grade distribution of fine aggregate from the graph deduced from the table. It is seen that the aggregate is of uniform fine grading.

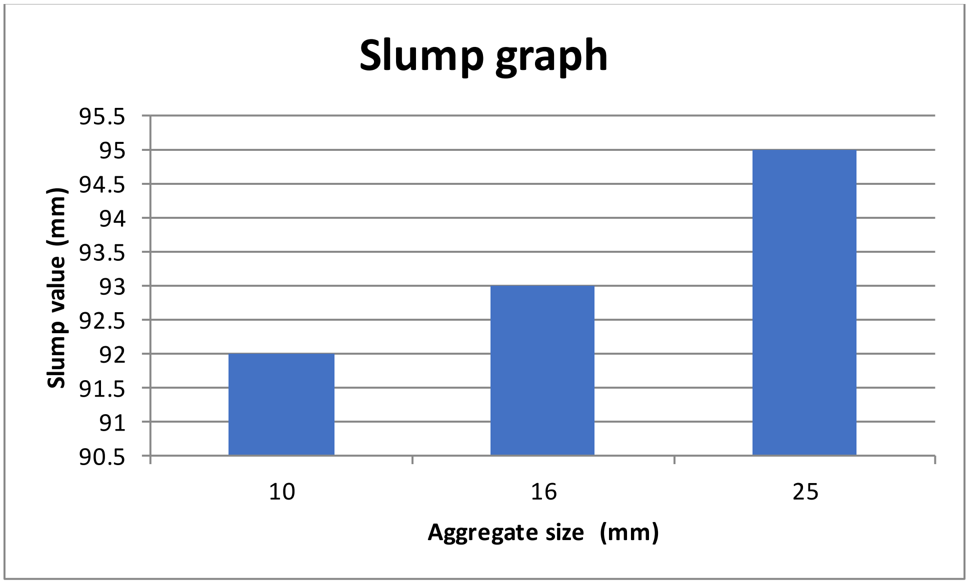
Figure 2 coarse aggregate sieve analysis graph



Aggregate Analysis (Coarse Aggregate)

The result of the test of the coarse aggregate from the graph shows that the coarse aggregate were well and uniformly graded.

Figure 3 Slump test graph

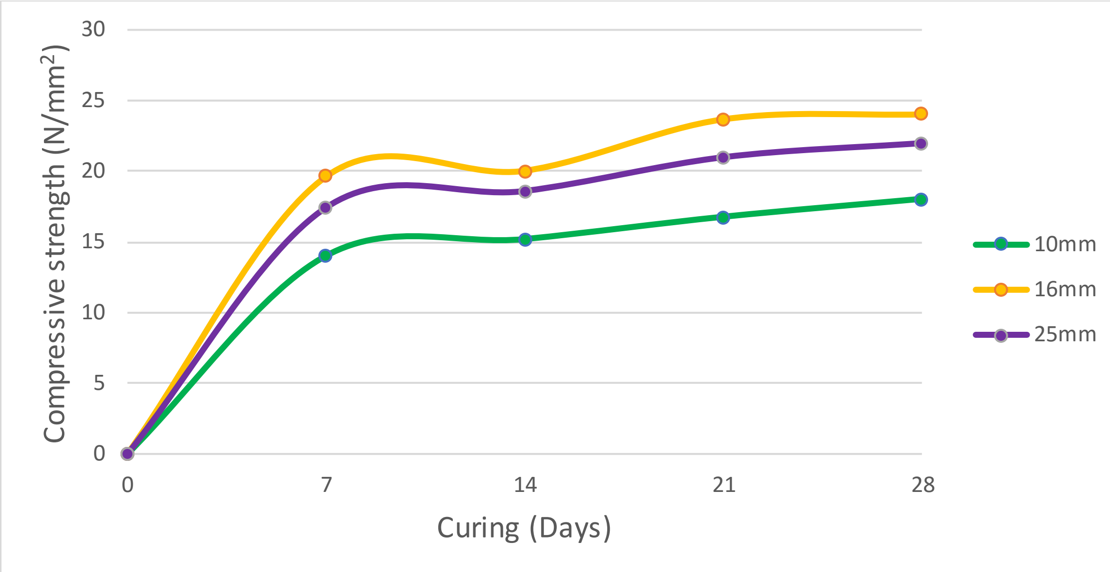


Workability

The workability of a concrete mix is affected by the mix proportion. Figure 3 above shows that for a given water cement ratio, workability decreases as the coarse aggregate size (proportion) increases in a concrete mix, this is probable because there is insufficient paste to lubricate the aggregate. It is also observed that the workability is decreased as the quality of fine aggregate is increased and this is likely due to the increase in the surface area of the aggregate proportion and the dryness of the concrete mix.

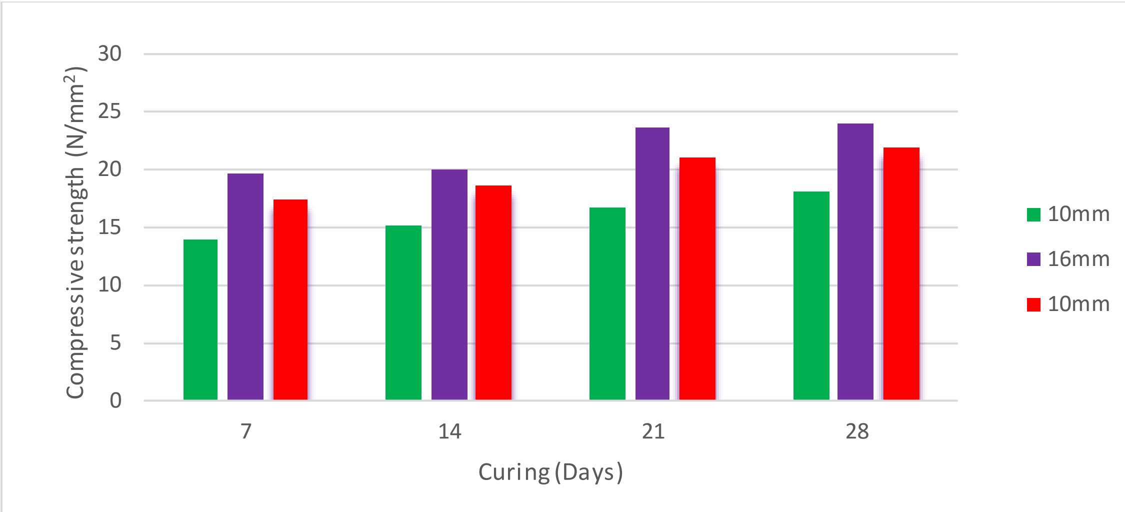
This result indicates that adequate paste content and aggregate surface area is required to achieve a certain degree of workability.

Figure 4 graph of coarse aggregate 10mm, 16mm and 25mm



The result of the compressive strengths of concrete specimen using a constant water cement ration are presented in the figure 4 above. It shows that the compressive strength increases progressively with increase in curing age for the different aggregate proportion in the concrete. Figure 4 also shows that the compressive strength of the concrete improved when the concrete aggregate proportion was varied i.e. when the concrete was slightly sandy and stony. It was also notice from the figure above that an early strength was obtained when the concrete was cured for the first seven days/ from the figure 4 about, the concrete made with coarse aggregate size of 16mm gave the highest strength gain followed by aggregate size 25mm and aggregate size 10mm

Figure 5 comparison of 10mm, 16mm and 25mm aggregate



From the chart above, it shows that the strength of concrete is affected by the variation in the aggregate size of the concrete. The compressive strength of the 16mm coarse aggregate size was highest because there was sufficient paste to completely fill all the voids in the concrete mix. This increase in strength as the curing age increases is in agreement with the finding of James etal, 2011 and Joseph etal, 2012.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

The compressive strength of the concrete has been measured at ages 7, 14, 21 and 28 days respectively. The tests are summarized in the tables above. The results from the crushing test shows in fig 4.3 shows that there is progressive increase in average compressive strength of concrete from 7-28 days respectively. The variation in numbers of days of curing increases the compressive strength of the concrete cube crushed. Observation shows that at 28 days, the concrete has achieved its maximum strength.

5.1 CONCLUSION

a. There is rapid increase in strength again during the first seven (7) days of curing followed by 14 days, 21 days and 28 days.

b. Concrete strength increase progressively with the age of curing.

c. Concrete gain its maximum strength at 28 days of curing

d. From the study, it can be concluded that the compressive strength of a Concrete is affected by the size, shape and surface texture of the aggregate.

e. It was observed that during the mixing of the concrete, the aggregate with the smallest surface area tends to be covered with cement paste wholly while the one with large surface area is not properly covered.

f. The curing days also affect the strength of the Concrete. As the curing days increases, the compressive strength also increase.

g. No matter the aggregate sizes, the failure patterns of the test specimens were the same. The failure patterns were pyramidal.

5.2 RECOMMENDATIONS

Based on the obtained results of the tests carried out and considering the importance of this investigation, the following recommendations are made

1. In this study, varying ages were used to obtain the compressive strength of concrete with different specimen of coarse aggregate (10mm, 16mm, and 25mm) and constant specimen of cement, water and fine aggregate. The author wish to suggest that other aggregates types within our area be used with the aim of determining the best aggregate size to be used in construction of reinforced concrete and mass concrete which should equally be more cost effective.

2. Machine mixing and machine compaction could be used in future studies for more uniform and adequate compaction to see if the compressive strength would be affected. The aggregate/cement ratios as well as water/ cement Ratio for aggregate type should be varied. The flexural and the tensile strength of the concrete with different aggregate sizes should also be studied to be able to draw a general conclusion.

3. Since there is increase and decrease in variation strength of concrete, it is good to conduct compressive strength of concrete without curing of the cubes to determine the compressive strength of the cubes

4. In this project, ten specimens (concrete cubes) were produced per aggregate type, only two samples were used for each of the 7, 14, 21, and 28 day tests. The author wishes to suggest that for effective study a greater number specimens per age be used in order to plot the best diagram

and obtain best fit curves. It will then be possible to observe the abnormal specimen(s) effectively at all water/ cement ratios and at all ages for each maximum size of aggregate.

5. from the test conducted for the compressive strength of concrete cast on different dates using different coarse aggregate size ,It is equally recommended that 16mm be used for reinforced concrete during construction since its compressive strengths are high while 25mm for mass concrete because of its low compressive strength.

6. Also for workability, the use of 10mm is recommended for beams and columns so as to achieve maximum compaction and less honey comb.

7. For the purpose of cost and economy in use of materials, the use of 25mm is recommended because of its large surface area.

8. Other types of cement should be used to see if the compressive strengths will be affected. And there should be awareness about the importance of recommending aggregate sizes for every structural element during design stage

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