EFFECT OF ADMIXTURES ON PROPERTIES OF CONCRETE CASE STUDIES OF SUGAR CANE SHAFT ASH, COW BONE ASH, GROUNDNUT SHELL ASH.

BY

JOHNNY, Simon

ENG18O4970

A PROJECT SUBMITTED IN

PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF

BACHELOR OF ENGINEERING (B.ENG).

IN

THE DEPARTMENT OF CIVIL ENGINEERING,

(STRUCTURAL ENGINEERING PROGRAMME)

FACULTY OF ENGINEERING,

UNIVERSITY OF BENIN

BENIN CITY, NIGERIA

TITLE PAGE

APRIL, 2024.

CERTIFICATION

This is to certify that this work was carried out by, JOHNNY SIMON Matriculation number ENG18O4970, of the Department of Structural Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria.

PROJECT COORDINATOR

Name: ENGR. EHI ORIA-USIFO

Signature: ……………………………… Date: …………………………………….

PROJECT SUPERVISOR

Name: ENGR. K. N. OGHOYAFEDO

Signature: ……………………………… Date: …………………………………….

HEAD OF DEPARTMENT

Name: ENGR. DR. MRS NGOZI IHIMEKPEN

Signature: ……………………………… Date: …………………………………….

DEDICATION

This project is dedicated to God Almighty and to my wonderful parents who has made countless effort towards making my academic journey successful and to my lecturers and professors for sharing their knowledge with me.

ACKNOWLEDGEMENT

My sincere thanks are sent to God Almighty, the Giver and the Creator of life, for keeping me safe during my time at the Great University of Benin and while I worked on this project. All glory belongs to Him alone.

My profound gratitude is extended to my project manager, Engr. N. K. Oghoyafedo, for his unwavering leadership and inspiration throughout this project, as well as for his relentless efforts in spite of his busy schedule.

I extend my sincere gratitude to Engr. Dr. Mrs. Ngozi Ihimekpen, the Head of the esteemed Department of Civil Engineering, for her immense influence on the department. Special appreciation is also extended to Engr. Prof. O. Iziyon, Engr. Prof. O. Orie, Engr. Prof. S.O. Osuji, Engr. Prof. H.P. Audu, Engr. Prof. J.O. Okovido, Engr. Prof. S.D. Iyeke, Engr. Dr. E. Nwankwo, Engr. Dr. S.E. Okonofua, Engr. Dr. Mrs. N. Kayode-Ojo, Engr. Dr. A. Rawlings, Engr. U. Ukeme, Engr. O. Osasu, Engr. Ehi Oria-Usifo, Engr. Dr. R. Ilaboya, Engr. Dr. Mrs. L.O Bobor, Engr. B. Omosefe, Engr. Urobosa as well as the whole administrative team of the University of Benin's Department of Civil Engineering for the incalculable amount of information they have affected during the course of this five-year study. God bless all of the technicians working at the Civil Engineering Laboratory.

My utmost gratitude goes to my parents, Mr. and Mrs. Johnny for all the love and support. May God continue to bless you all.

Finally, special thanks to all of my friends and classmates who supported me throughout this education. I pray that God will also be there for you when you need him

ABSTRACT

The project titled "The effect of admixtures on properties of concrete: case study of sugar cane shaft ash, cow bone ash, groundnut shell ash," will be carried out with the aim of knowing the effect the of the various types of admixtures used on the properties of concrete, in term of the workability of concrete, durability of concrete and the concrete strength.

The material used are cow bone ash, groundnut shell ash, sugar cane shaft ash. The cow bone will be sourced along new Benin market, Edo state and the groundnut shell will be sourced from uselu market. The cow bone will be sun dried after careful separation from flesh, tissues and fats, the ash will be carried out by incinerating the bone at a temperature of 900ºC in a furnace. Also, the groundnut shell ash will be obtained by burning groundnut shell on an iron sheet in the open air under normal temperature while sugar cane shaft ash. The method adopted will be; batching of concrete materials, mixing of concrete materials, production of cubes, curing of cubes (for 7days, 14days and 28days) while the test carried out during and after the concrete cubes are produced or casted are; sieve analysis test, slump test and compressive strength test. From the sieve analysis test carried out on both fine and coarse aggregates, it will be discovered that the coefficient of uniformity (C_u) obtained are less than 4, hence they are both "well-graded" aggregates. The slump test shows that there is increase in the slump value from sugar cane shaft ash-concrete, GSA-concrete, CBA-concrete and LP-concrete, likewise the compressive strength test increases from sugar cane shaft ash-concrete, GSA-concrete, CBA-concrete and LP-concrete. From the findings, it is evident that the combination of the three admixtures resulted in the highest percentage increase in compressive strength. Additionally, the average maximum strength was achieved when the fine aggregate was replaced by 15% with the admixture. Despite variations in replacement percentages, all samples exhibited compressive strengths that align with the expected design characteristics of concrete, particularly around the target value of 20 KN/mm^2. The sieve analysis further revealed a well-graded particle size distribution in the fine aggregate samples, indicating suitability for achieving optimal concrete mix designs.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

The importance of understanding various types of materials used in Civil Engineering is widely recognized. There has been tremendous increase in the latest research and practical achievement to improve on concrete technology (Santha Kumar, 2007).

Concrete is a composite material which is formed by mixing in good proportion, cement, water, fine aggregate and coarse aggregate, air and at times admixture. Freshly prepared concrete is called Wet or Green concrete. Concrete is the most widely used construction material globally due to its versatility, durability, and affordability (Makul and Natt, 2020). Traditional concrete consists of cement, aggregates, water, and admixtures, with the latter playing a crucial role in modifying and enhancing its properties (Kujawa et al., 2021).

However, the properties and performance of this concrete are being influenced by the introduction of some materials called admixture. Admixtures have been in use almost since the inception of the art of concreting. It is reported that the roman builders used oxblood as an admixture in their concrete and masonry structure. Research has shown that oxblood is an excellent air entraining agent. During the early part of this century, it will be a common practice to add gold dust, soap to concrete as water proofing agent. Admixtures are materials other than water, cement, aggregate and additives like pozzolana or slag and fiber reinforcement, used as an ingredient of concrete or mortar and added to the immediately before or during its mixing to modify or alter one or more properties of the concrete in the Admixture or hardened state.

Admixtures are substances added to concrete during mixing to achieve specific objectives such as improved workability, reduced water demand, enhanced strength development, and increased durability (Cheung et al., 2018). The use of admixtures has become increasingly prevalent in modern construction practices as engineers seek to optimize concrete performance and sustainability (Makul and Natt, 2020).Admixtures are classified as either mineral admixture which may be introduced as blended materials such as f, silicate fume, ground granulated blast furnace slag, meta kaolin, and rice husk ash or chemical admixture which are typically added during the mixing process of concrete production, its include accelerators, retarders, air entrainer, Plasticizer or water reducer, water proofers and pigments (Akogu and Elijah Abalaka, 2011).

In summary, the exploration of unconventional admixtures such as sugar cane shaft ash, cow bone ash, and groundnut shell ash represent a significant opportunity to enhance the performance and sustainability of concrete. Through comprehensive research and experimentation, a deeper understanding of the effects of these admixtures on concrete properties can be gained, leading to more efficient and environmentally friendly construction practices. This study seeks to contribute to this body of knowledge by investigating the specific impacts of sugar cane shaft ash, cow bone ash, and groundnut shell ash admixtures on various aspects of concrete performance.

1.2 STATEMENT OF THE PROBLEM

The effective utilization of concrete admixtures in civil engineering projects poses both challenges and opportunities. While admixtures can enhance various properties of concrete, not all are cost-effective or necessary for every project. It's essential to assess the specific requirements of each project to determine which admixtures, if any, are suitable for achieving the desired concrete characteristics within the constraints of cost and practicality. For instance, while some admixtures may offer benefits such as improved workability or reduced water content, these advantages must be weighed against their associated costs and the availability of alternative methods to achieve similar outcomes through rigorous adherence to high-quality concreting practices.

Concrete admixtures are complex chemistry that require a deep understanding to ensure their effective application. They interact with concrete constituents in complex ways, affecting its setting time, strength development, durability, and other properties. Selecting the appropriate admixture requires knowledge of its chemical composition, its interaction with the specific mix design, environmental conditions, and intended application of the concrete. Engaging experienced professionals is crucial for navigating the complexities of concrete chemistry and tailoring solutions to meet unique project requirements. A comprehensive strategy considering project requirements, long-term performance objectives, and climate conditions is essential when choosing admixtures. Accelerating admixtures can speed up concrete curing and achieve early strength increase in projects with quick construction timelines. Project stakeholders can optimize the performance and cost-effectiveness of the concrete mix by carefully weighing these elements and consulting concrete technology specialists.

1.3 AIM AND OBJECTIVE OF THE STUDY

The aim of this project is to determine the effects of sugar cane shaft ash, groundnut shell ash and cow bone ash admixtures on the properties of concrete.

The objectives of the study are alighted below:

1. To carry out a slump test on concrete to know its effect with admixture in terms of durability, setting time and workability.
2. To carry out a compressive strength test on concrete with admixture in comparison to controlled concrete without admixtures.
3. To determine the mechanical properties (AIV and ACV) of aggregates.
4. To conduct particle size distribution of aggregate.
5. To carry out a cost benefit analysis on admixtures.

1.4 SCOPE OF STUDY

The scope of this project is basically the effect of admixture on the properties of concrete. In view of the above facts, the extent at which some of the admixture reduces or enhances the properties of concrete is a motivating factor on this project. In this project sugar cane shaft ash, groundnut shell ash, cow bone ash will be considered.

The study shall include

1. Consistency test of cement and admixture such as sieve analysis, slump, and compressive strength etc. would be carried out on the samples.
2. Mechanical properties of aggregates which include AIV and ACV test.
3. Acquisition of materials (sugar cane shaft ash, groundnut shell ash, cow bone ash, cement, aggregate).
4. Analysis of data obtained from laboratory tests.
5. Comparison of result obtained and conclusion based on result.
6. Recommendations for further studies.

1.5 JUSTIFICATION OF STUDY

Admixture has been in use for a very long time, such as calcium chloride to provide a cold-weather setting concrete. Others are more recent and represent an area of expanding possibilities for increased performance. These types of admixtures are available in two forms, which are mineral or chemical admixture. Admixture like fly-ash, silicate fume, and slag comes in category of mineral admixture, while chemical admixtures are super plasticizers, accelerator, water reducer, retarder and air entrainer.

Admixtures are used to modify the properties of concrete such as to improve workability, curing temperature range, setting time, increase strength, retard or accelerate strength development, reduce segregation, decrease or reduce permeability, increase bond of concrete to steel reinforcement, increase durability or resistance to severe condition of exposure.

Generally, an admixture will affect more than one property of concrete and its effect on all the properties of the concrete must therefore be considered. Admixture may increase or decrease the cost of concrete by reducing cement quantity required for a given strength changing the volume of the mixture, or reducing the cost of concrete placing and handling operations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The literature review provides a comprehensive overview of existing research and studies related to the effects of admixtures on concrete properties, with a focus on sugar cane shaft ash, cow bone ash, and groundnut shell ash. This chapter aims to synthesize and analyze the findings of previous studies, identify gaps in the literature, and establish a theoretical foundation for the current research.

According to Wazumtu and Ogork (2015), who did research on the topic "Assessment of Groundnut shell ash (GSA) as admixture in cement paste and concrete". The effects of GSA on cement paste and concrete were investigated for addition of 0, 1, 2, 3, 4, 5 and 6% respectively by weight of cement.

The result of the investigations showed that GSA was predominantly of calcium oxide (24.10%), potassium oxide (21.90%) and combined SiO_2, Al_2O_3 and Fe_2O_3 content of 29.04%. The addition of GSA in cement or concrete decreased drying shrinkage, slump and water absorption; but increased consistency, initial and final setting times and could be used as a retarder. Also, GSA addition showed increase in compressive strength, with an optimum of 4% GSA and that the used of GSA in concrete also offered a better resistance to sulphuric acid environment.

According to Beeralinge and Gundakalle (2013), on the topic "The effect of addition of limestone powder on the properties of self-compacting concrete". In this study, cement content in the self-compacting concrete (SCC) mix is replaced with various percentages of limestone powder (LP) (0 to 30%), the fresh and hardened properties and also the durability characteristics of SCC such as acid attack and chloride attack are studied. The experimental results were validated by regression analysis. It is observed that limestone powder can be effectively used as a mineral admixture in SCC.

According to Akinleye et al. (2016) on the topic “The effect of Partial Placement of Cement with Bone Ash and Wood Ash in Concrete”, cement was partially replaced in concrete at 5, 10, 15, 20, and 25% with both bone and wood ashes. Chemical analysis was carried out on both the wood and bone ashes in order to determine their pozzolanic properties while compressive strength test was conducted on the concrete obtained from both cement replacements. The chemical analysis revealed that the bone ash is a better pozzolanic when compared to the wood ash. The compressive strength test showed that the wood ash is not a good material for replacing cement in concrete, while 10% of bone ash can partially replace cement in concrete 28 days compressive test.

Oyekan (2007), successful worked on improving the compressive strength of concrete block by the addition of sugar cane shaft ash 0.1% sugar cane shaft ash content (by weight of cement). The 28 days strength of the blocks was increased by only 9% but the 14days strength of the block was increased by only 9% but the 14days strength of the bodies was increased by 56.6%.

Akogun (2011), a successful work on sugar cane shaft ash at concentration at 0.05% by weight of sugar cane shaft ash content were taken on the cement paste with C33 concrete cunning at 3, 7, 14 and 28 days was investigated by use of ordinary Portland cement. The compressive strength test results show some marginal strength gains at all ages but peak at 11.84% at 3 days at 0.05%.

2.1 Concrete

2.1.1 Ancient Origins

Around 6500 BC, in Syria and Jordan, a crude mixture of lime, volcanic ash, and stones was utilized to create the first materials that resembled concrete (Hofgård and Sundkvist, 2020). Concrete with climate enhancement in the field of civil engineering. Notably, the Great Pyramid of Giza in Egypt, built in 2550 BC, is a prime example of the early application of mortar made of gypsum and limestone.

2.1.2 Evolution of Techniques

Concrete technology experienced significant advancements in ancient Rome. The Romans, particularly skilled in concrete use, employed a mix of volcanic ash, lime, and rubble. This innovation is evident in iconic structures such as the Pantheon and the Colosseum (Tan, 2012).

2.1.3 Versatility of Concrete

Concrete's versatility allowed the creation of intricate architectural designs, including arches and domes (Wrightson, 2022). This adaptability contributed to the construction of complex structures, showcasing its moldable nature.

2.1.4 Benefits of Concrete

Concrete's durability, strength, and resistance to fire and weathering make it a crucial construction material (Amran et al., 2022). Its moldable properties have enabled the realization of various architectural designs, emphasizing its indispensable role in construction.

2.1.5 Issues Associated with Concrete Use

While concrete offers numerous advantages, challenges exist, including cracking due to shrinkage, susceptibility to chemical attacks, and environmental concerns related to cement production (Makul, 2020). Addressing these challenges is crucial for sustainable concrete use.

2.2 Composition of Concrete

Concrete is a composite material with a complex composition, consisting of various components that work together to provide its distinctive properties.

2.2.1 Cement

An essential component of concrete, cement is what holds the other ingredients together. The most popular kind is Portland cement, which is made by grinding clinker and a tiny quantity of gypsum (Kosmatka, Kerkhoff, and Panarese, 2002). The hardening and setting processes in concrete are started by the chemical interaction of cement and water, which generates a paste.

2.2.2 Aggregate

Aggregates, comprising coarse and fine particles, occupy a significant portion of concrete. Coarse aggregates, such as gravel or crushed stone, provide structural strength, while fine aggregates, typically sand, contribute to workability (Yaragal et al., 2019). The proper distribution and proportion of aggregates influence the concrete's overall performance.

2.2.3 Admixture

Admixtures are additional substances introduced to modify concrete properties during mixing or placement. These can enhance workability, accelerate or delay setting time, or improve durability (Shah et al., 2014). Common types include water reducers, accelerators, and air-entraining agents.

2.2.4 Water

Water is a vital component that initiates the chemical reaction with cement, leading to the hydration process. The quality of water used in concrete significantly impacts its final properties. Excessive impurities or improper water-cement ratio can affect the strength and durability of the concrete (Mindess, Young, and Darwin, 2003).

2.3 Concrete in Practice

Concrete is a composite material with the properties that change with time. During service, the quality of concrete provided by initial curing can be proved by subsequent wetting as in the case of foundation or water retaining structures. However, concrete can also deteriorate with time due to physical and chemical attacks.

2.3.1 Types of Concrete

1. Normal concrete
2. High-strength concrete
3. High performance concrete
4. Air-entrainment concrete
5. Light weight concrete
6. Self-compacting concrete

The strength of concrete is influenced by the following factors;

1. Quality of raw material
2. Water – cement ratio
3. Type, proportion, grading of aggregate used
4. Type and proportion of cement
5. Water content
6. Addition of admixture

7. Age of concrete
8. Creep
9. Segregation
10. Shrinkage
11. Bleeding
12. Compaction of concrete

Salt water does not have adverse effect on the strength and durability of concrete but known to cause surface dampness efflorescence and staining. Insufficient quantity of gypsum in concrete causes an immediate stiffening of cement paste with large amount of heat generated while further addition of it will reduce the heat generation and lower the setting time.

Admixture when added to concrete in large quantities affects the strength of concrete as well as all other properties. Sugar cane shaft ash cause lack of proper cohesion and adhesion in concrete mix. It therefore retards the setting time of concrete. For an aggregate to be suitable for construction use the graph of the aggregate grade, for the aggregate sample must lie within the upper and lower limits of the standard grading. For workability test slump varies from 20mm for vibrated mass concrete to 130mm for heavily reinforced non vibrated concrete.

Granite which is called coarse aggregate as one of the concrete components should be hard, well shape, clean and fire resistance in nature while sand which is fine aggregate should be clean, free from clay and durability for concrete.

Cement which is the finest of all particles in concrete mix should be rich to produce strong, dense and durable concrete while water for concrete mix should be fresh, clean, and free from oil, acid, organic matters and solution due to pollution from industrial waste or similar drainage.

Setting time of cement are measured using the vicat apparatus with different penetrating attendant. For the determination of the initial set, around needle with a diameter 1.13 ± 0.05mm is used. When the cement paste stiffens sufficiently for needle to penetrate only to a point 5 ± 1mm from the bottom, initial set is said to have taken place. Initial set is expressed as the time elapsed since the mixing water was added to the cement. BS 12:1975 prescribed a minimum time of 45 minutes.

Final set is determined by a similar needle fitted with a metal attachment hollowed out, so as to leave a circular cutting edge 5mm in diameter and set 0.5mm behind the lip of the needle, gentle lowered to the surface of the paste, makes on impression on it, but the water circular cutting edge fails to do so. The final setting time is reckoned from the moment when mixing water was added to the cement, and is required of the relevant British standard to be not more than 10hrs.

2.4 Type of Admixtures

Rixon and Mailvaganam (1986), admixture in concrete mix will influence the workability of concrete, voids percent, water absorption percent, strength and durability of the concrete, therefore it is necessary to classify or group admixtures according to the purpose for which they are used in concrete. They can be grouped as:

2.4.1 Accelerators

The use of accelerating admixtures is common during cold-weather concreting, as the rate of hydration of cement is decreased by lower temperatures. Their function is to increase the rate of hydration, thereby speeding up the setting time and early strength development. Examples of accelerators are calcium chloride, calcium nitrite, calcium chloride is commonly used but the use of calcium nitrite (also called a corrosion inhibitor) leads to a better strength gain at later ages than calcium chloride. Excessive amount of calcium chloride in concrete mix may results in several adverse effect such as increased drying, shrinkage, reduced resistance to sulphate attack and increase risk of corrosion of steel reinforcement, it should only be used with extreme caution and in accordance with any relevant specifications. It may usefully be employed for concreting in winter condition, emergency repair or where early removal of formwork were required.

2.4.2 Retarders

Slow down the hydration of cement, their function is to delay or extend the setting time of cement paste in concrete. They are used mainly in hot weather conditions in order to overcome the accelerating effects of higher temperature and large masses of concrete-on-concrete setting time. Because most retarders also act as water reducer. As per chemical admixture classification by ASTM C494, type B is simply admixture, while type D is both retarding and water reducer, resulting in concrete with greater compressive strength because of the lower water-cement ratio.

Retarding admixtures are used; Where long transportation of ready mixed concrete is required then premature setting can be usefully avoided by this type of admixture, when concrete is being placed or transported under conditions of high ambient temperature, In case of large concrete pours, Concrete construction involving sliding formwork.

Retarding admixtures consist of both organic and inorganic agents. Organic retardants include: Unrefined lignosulphonates containing sugar cane shaft ash, which of course the component responsible for retardation, Hydroxyl carboxylic acid and their salts, Carbohydrates including sugar cane shaft ash, Unrefined calcium, sodium and NH_4.

While inorganic retardants include; oxide of lead and zinc, phosphates, magnesium salt fluorides, soluble zinc, soluble borates etc.

2.4.3 Air-entrainers

These are probably the most important group of admixtures. They improve durability of concrete; in particular, its resistance effect of frost and de-icing salts. The entrainment of air in the form of very small and stable bubbles can be achieved by using framing agents based on natural wood resins, animal or vegetable fat and synthetic detergents which promote the formation of air bubbles during mixing or by using gas-producing chemicals such as zinc or Aluminum powder which react with cement to produce gas bubbles. other air entraining agent are neutralized vinsol resins, polyethylene oxide polymers and sulphonated compounds. First method is generally more effective and widely used. The beneficial effect of entrained air is produced in two ways:

First, by disrupting the continuity of capillary pores and thus, reducing the permeability of concrete, and second, by reducing the internal stresses caused by the expansion of water on freezing.

Air-entrainers also improve the workability and cohesiveness of fresh concrete, ease of placing, tend to reduce bleeding and segregation. However, entrained air result in some reduction in concrete strength since improvements in workability can permit a reduction in water content, the loss in strength can be minimized, the amount of entrained air depends on the type of cement, mix proportions and ambient temperature and it should therefore be used only when adequate supervision is assured.

2.4.4 Water reducer or Plasticizers

Most retarders are also used for this purpose for example lingo-sulphuric and hydroxylated carboxylic acids. other water reducing agent is calcium or sodium salt of lingo-sulphuric acid and poly carboxylic acid. Their effect is tough due to the increase in dispersion of cement particles causing a reduction in the viscosity of the concrete.

Water reducers or Plasticizers are used for the following;

Concrete having greater workability be made without the need for more water and so strength losses are not encountered,

By maintaining some workability, but at a lower water content, concrete strengths may be increased without the need for further cement addition,

While maintaining the same water-cement ratio and workability concrete can be made to a given as in the reference concrete at lower cement content.

2.5 Selected Agent

This section provides a comprehensive overview of existing research and studies related to the different selected agents otherwise known as admixtures on concrete properties, with a focus on sugar cane shaft ash, cow bone ash, and groundnut shell ash.

2.5.1 Sugar Cane Shaft Ash

According to Annals of Faculty Engineering Hunedoara – International Journal of Engineering (Tome, 2016). Describes sugar cane shaft ash as a white crystalline solid that is easily schedule in water and easily available in market. Sugar cane shaft ash can be use in the concrete production as an admixture by adding it into concrete mix based on percentage (say 5%, 10% and 15%) by weight of cement.

Sugar cane shaft ash is a water-soluble crystalline mono or polysaccharide C_{12} H_{22} OH is disaccharide which can be split as shown below by hydrolysis

C_{12} H_{22} 0_{11} + H_{20} → $C_6H_{12}O_6$ + $C_6H_{12}O_6$

Sucrose Water Glucose Fructose

2.5.2 Groundnut Shell Ash (GSA)

Industrialization in developing countries has resulted to increase in agricultural output and consequent accumulation or unmanageable waste. Groundnut shell is a waste from agricultural product which is usually burnt, dumped or left to delay naturally. It constitutes about 25% of the total pod (Shell and Seeds) mass and may be a nuisance to both health and environment when not properly disposed, these may create large number of coasts by product that must be transported away and stored in landfills.

The pollution a rising from such waste is a cause of concern for many developing nations such as Nigeria. The use of admixture in concrete is necessary in situations where there is a need to enhance the properties of either fresh or hardened concrete or both for a particular purpose. In most situations the realization of such improvement can only be achieved effectively and more rapidly when appropriate admixtures are used.

The choice to investigate into use of GSA as admixture in cement paste and concrete may serve as a cheaper alternative to that if conventional admixtures, with a consequent reduction in the cost of construction and also as a means of addressing the environmental pollution caused by the accumulation of the waste. Groundnut shell was sourced from oba market Benin city. The Groundnut Shell Ash (GSA) was obtained by controlled burning of the shell in an incinerator to a temperature of 600^{o}c and after cooling was sieved through a 75nm sieve and characterized.

The GSA obtain was packed in polyethene bags to prevent water absorption and for water proofing and stored in a cool and dry place.

2.5.3 Cow bone Ash (CBA)

Cow Bone causes serious disposal problem and continue to accumulate at increasing rates, which if not properly managed, the bone will create increasing environmental problems. For this reason, utilization of the bone as sustainable material in concrete production would help to preserve natural resources and maintain ecological balance. Many studies have been conducted to determine the mechanical properties of both fresh and hardened concrete partially replaced with cow bone ash.

Cow Bone was obtained from the abattoir in new Benin market. The cow bones were sun dried after careful separation from flesh, tissues and fats. The ash was obtained from burning cow bone at a temperature of 900^{o}c in a control furnace only the organic matter was destroyed leaving a mass of bone salt. The mass of bone salt was allowed to cool before reducing to a fine powder using mortar and piston. The reduced fine powder was further passed though 75mm size sieve to obtain finer particles, the ash was ashy in colour. The fraction passing though 75mm was packed in polythene bags to prevent water absorption and for water proofing and stored in a cool dry place.

2.6 Materials for Concrete

2.6.1 Aggregates

Yusuf (2015), said aggregate can be define as a granular material for mineral composition such as sand, gravel, shell, slag or crushed stone, used with a cementing medium to form mortar concrete or alone as a base course etc. Approximately three-fourth of the volume of conventional concrete is occupied by aggregate consisting of such materials as sand, gravel, crushed rock or air-cooled blast furnace slag. It is necessary that a constituent occupying such a large percentage of the mass should contribute greater strength to both Admixture and hardened product.

Aggregates are classified into:

1. Fine aggregate
2. Coarse aggregate
3. All in aggregate

2.6.1.1 Fine Aggregate

These are aggregate whose particles pass through 4.75mm mesh and entirely retrained in 0.15mm mesh. Most commonly use fine aggregate are sand, stone, dust, ashes etc.

2.6.1.2 Coarse Aggregate

These are aggregate whose particle sizes are bigger 4.75mm but smaller than 3.75mm example granite, gravel, brick blast.

2.6.1.3 All in Aggregate

This is the combination of both fine and coarse aggregate. Material between 0.06mmm and 0.002mm is classified as silt and particle smaller than slit are termed clay.

Roberto et al. (1996) describes aggregate physical properties as the most readily apparent properties and they also have the most direct effect on how the aggregate performs as either a pavement material constituent or by itself as base sub base material. Roberto further said aggregate as voids, and there are voids between aggregate particles. As solid as aggregate maybe for the naked eyes, most aggregate as voids which are natural pores that are filled with air or water. These voids or pores influence the specific gravity and absorption of the aggregate material.

Examples of aggregate are:

1. Gravel: They are granular substance predominantly retained in 4.75mm sieve and resulting from material disintegration and abrasion of rock or processing of weekly bound conglomerate.
2. Sand: Are granular material passing through the 4.75mm sieve and predominantly retained in 75mm sieve, and resulting from natural disintegration and abrasion of rock or processing of completely friable sandstone.
3. Crushed Stone: The product result from the artificial crushing of rocks, boulders or large cobble – stone, substantially all faces of which have resulted from the crushing operation.

4. Air Cooled Blast-Furnace Slag: This is a material resulting from the solidification of molten blast – furnace slag under atmospheric conditions. Subsequent cooling may be accelerated by the application of water to the solidified surface.
5. Crushed Gravel: This is a product resulting from the artificial crushing of gravel with substantially all fragments having at least on face resulting from fracture.

2.6.2 Cement

Salami (2002), said cement can be describe as a material with adhesive and cohesive property which bind together the particles of aggregate usually sand and granites to form a mass of high compressive strength known as concrete.

Cement cannot be shown by a chemical formula as it is complex mixture of several compounds. However, there are four compounds computed from the oxide analysis of cement that for all practical purpose may be considered as comprising the cement. The main compounds with their commonly accepted abbreviation are;

Tricalcium silicate = C_3S

Dicalcium silicate = C_2S

Tricalcium silicate = C_3A

These compounds as they called are not true compounds in the chemical sense but the computed proportions of these compounds reveal valuable information concerning the cement strength – developing characteristics of cement depend on the C_3S and C_2S which comprises about 75% of the cement. The C_3S hardens rapidly and therefore has a major influence on setting time and early strength; hence a high proportion of C_3S result in high early strength and high heat hydration C_2S on the other hand hydrates more slowly and contributes to strength gain, C_3A contributes to high early strength and high heat but result in undesirable properties of concrete, such as poor sulphate resistance and volume change.

2.6.3 Physical Properties of Cement

2.6.3.1 Fineness

Is the sub division of substances. The rate of hydration of cement depends on the fineness of cement particles, and for a rapid development of strength high fineness is necessary. Achievement of fineness is carried out at the final step of manufacturing cement, where clinker is grinded with gypsum. Cement particles because it is smaller in size it cannot be separated by using sieve and other method of measuring particles size. The specific method is commonly used in which the particles of cement of cement are considered to be spheres. The specific surface is the summation of the surface area in square centimeter of the particles in l gram of cement.

The Wagner turbidimeter is based on the principle that turbidity is a measure of the surface area of a sample of cement. Turbidity is determined at interval by measuring with photoelectric cell.

2.6.3.2 Setting Time

Setting is the term used to describe stiffness of cement paste. The beginning of noticeable stiffening in cement paste is known as initial setting. Further stiffening in cement occurs as the volume get increases and the stage at which this is complete called final set. It is grouped into two;

1. Flash Set: It is immediate stiffening in cement. It takes place in cement with insufficient gypsum to control the rapid reaction of C_3S with H_2O. These reactions generate a considerable amount of heat and cause the cement to stiffen in few minutes after mixing. This can only be overcome by adding more water and regulate the mix.

2. Flash Setting: A false setting also produces a stiffening of paste but not accompanied by excessive heat. In this case remixing the paste by not further addition of water causes it to regain its plasticity and its subsequent setting and hardening characteristic are quite normal.

The setting time of cement is measured using the vicat apparatus with different penetrating attachment. For the determination of the initial set a round needle with a ϴ1.13±0.05mm is used when the cement paste stiffens sufficiently for needle to penetrate only to a point 5± 1mm from the bottom initial set is said to have taken place. Final set is determined by similar needle fitted with metal attachment hollowed out so as to leave circular cutting edge 5mm in ϴ and 0.5mm behind the top of the needle. Final set is said to have taken place when the needle gentle lowered to the surface making an impression on it but the circular cutting edge fails to do.

2.6.4 Water

Water is used in concrete to facilitate mixing, placing and compaction of fresh concrete. It is also use for washing the aggregate and curing in order to ensure proper hydration. However, water to be used should be satisfactory if it is portable, it should be reasonable, clean and free from organic matter, salt and silt.

The water cement ratio is the ratio of the weight of the cement used in concrete mix and has an important influence on the quality of concrete produced. A lower water – cement ratio leads to higher strength and durability, may make the mix more difficult to place. The concept of water – cement ratio was developed in by (Duff Abram, 1918).

2.6.4.1 Quality of Water

The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid salts, sugar cane shaft ash, organic materials, vegetable growth and other substances. Portable water is generally considered satisfactory for mixing. The PH of water should not be less than 6. (Amit Hasija, 2008).

2.6.4.2 Properties of Water

1. PH: pH is a method of expressing differences in the acidity or alkalinity of a solution or water sample.
2. Turbidity: This is a measure of the extent to which height can be absorbed or scattered by suspended materials in water.
3. Colour: Water when should be colourless. Water tends to have colour when substances like leaves, weeds and so on dissolve in it.
4. Temperature: This is how hot or cold water is. It affects chemical reactions that can take place in water as well as its density (Amit Hasija, 2008).

2.6.5 Curing

In order to obtain good concrete, the placing of an appropriate mix must be followed by curing in suitable environment during the early stages of hardening. Curing is the name given to procedures used for promoting the hydration of cement and consists of a control of temperature and of the moisture movement from and into the concrete. The main object of curing is to keep concrete saturated as possible, until the originally water filled to the desired extent by the products of hydration of cement. According to Polivkum and Klein (1960), curing concrete is the term used for stopping freshly poured concrete from drying out quickly. The reason why this is done is that concrete, if left to dry out of its own accord, will not develop the full bond between all of its ingredients.

2.6.6 Soundness

It is essential that cement does not undergo large changing in volume after setting. This change in volume is known as unsoundness and it is caused by excessive line or magnesia in cement given rise to cracks, distort and disintegration of concrete (Yusuf, 2015).

CHAPTER THREE

METHODOLOGY

This chapter describes the process used to evaluate the effects of admixtures on properties of concrete limited to sugar cane shaft ash, cow bone ash, groundnut shell ash and a combination of the three. For successful accomplishment of the aims and objectives of this project the following methods are applied. Market survey for the most commonly used cement was carried out and it was found that elephant and Dangote cement are the most commonly used in the locality due to their availability in the market all time. Sieve analysis test is conducted in accordance with (B.S 882 or B.S 1021 of 1972) to confirm the presence of the desire aggregate sizes.

Preparation of concrete and casting of the cubes. Concrete sample are mixed in the ratio 1:1.6:4.4 first without admixture and later with admixture. The proportion of admixture used varied by 5% interval (5,10 and 15% respectively). Three cubes are casted for every percentage change in the proportion of admixture for each of the agent used. Slump test is done to determine the workability and consistency of concrete mix in accordance with British Standards Institution. The compressive strength of concrete cubes can be obtained from (Eqn 3.1) below.

$$\text{Compressive Strength } (N/\,mm^2) = \frac{\text{Maximum Load (KN)}}{\text{Cross Sectional Area } (mm^2)} \qquad (3.1)$$

The experimental investigations will be conducted at the University of Benin's Civil Engineering Department's structural laboratory.

The subsequent examinations will be carried out in compliance with pertinent guidelines and standards (BS1881) to evaluate the characteristics of the concrete:

(i) Particle size distribution

(ii) Aggregate impact value test

(iii) Aggregate crushing value test

(iv) Slump test

(v) Compressive strength test

For all formulations, the water-to-cement ratio (w/c) will be kept constant at 0.5 to provide uniform workability.

Admixtures will be added to concrete mixture in all tests at percentages of 0%, 5%, 10% and 15% respectively. This is ratio of replacement is shown in table 3.1, stating various admixtures and their varying percentage replacements.

Table3.1 Showing the Ratios of Replacement (Mix Design Calculation)

MIX PROPORTIONS RATIOS FOR THE REPLACEMENT					
MIX TYPE	**CONCRETE**	**SUGAR CANE SHAFT ASH**	**COW BONE ASH**	**GROUNDNUT SHELL ASH**	**COMBINATION OF THE THREE ADMIXTURES**
Control Mix	100%	0%	0%	0%	0%
Mix A	100%	5%	0%	0%	0%
Mix B	100%	10%	0%	0%	0%
Mix C	100%	15%	0%	0%	0%
Mix D	100%	0%	5%	0%	0%
Mix E	100%	0%	10%	0%	0%
Mix F	100%	0%	15%	0%	0%
Mix G	100%	0%	0%	5%	0%

Mix H	100%	0%	0%	10%	0%
Mix I	100%	0%	0%	15%	0%
Mix J	100%	0%	0%	0%	5%
Mix K	100%	0%	0%	0%	10%
Mix L	100%	0%	0%	0%	15%

3.1 Materials

The laboratory-produced concrete cubes will be made using the following materials.

1) Coarse Aggregate (granite)

2) Fine Aggregate (sand)

3) Cement (OPC)

4) Admixtures (sugar cane shaft ash, cow bone ash, groundnut shell ash)

5) Water

6) Oil

3.1.1 Ordinary Portland Cement (OPC)

Ordinary Portland cement (OPC) of grade 42.5 (also known as Dangote cement) that complied with applicable specifications will be utilized in this investigation. This came from an Edo State cement depot near the university of Benin, ugbowo campus. The cement will be kept airtight, only being opened to take a sample when required in order to avoid absorbing moisture.

Table 3.2a Physical Properties of Cement (Rafat Siddique et al., 2014)

S/N	Property	Values
1	Fineness of cement (%)	7
2	Normal consistency (mm)	33

3	<u>Setting time</u> Initial (minutes) Final (minutes)	 85 124

According to Table 3.2a, it met according to the standard specifications BS8112:1989.

Table 3.2b Chemical Properties of Cement (Rafat Siddique et al., 2014)

S/N	Property	Values
1	Lime	60.87
2	Alumina	5.36
3	Soluble silica	20.55
4	Iron oxide	4.00
5	Chloride	0.0173
6	Magnesia	0.74
7	Sulfuric Anhydride	1.83
8	Insoluble residue	2.93
9	Al_2O_3/Fe_2O_3	1.34

Chemical composition of cement according to Table 3.2b, was determined according to the standard specifications ASTM C 311.

3.1.2 Admixtures

Sugar Cane Shaft Ash, Groundnut shell and Cow bone will be sourced from Benin metropolis. The ash will be obtained by burning both Groundnut shell and Cow bone to a cold temperature in an incinerator and controlling the fire at that temperature for about an hour, the ash will be then allowed to cool.

3.1.3 Fine Aggregate

The fine aggregate will be purchased locally from Uselu market in Ovia North-East L.G.A. of Edo State. The fine aggregate will be air dried before casting to make sure that its natural moisture content will be reduced to the point where it could not have an impact on the test results.

Table 3.3 The Properties of the Fine Aggregate (Rafat Siddique et al., 2014)

S/N	Property	Value
1	zone	II
2	Percentage passing by weight	80-100%
3	Bulk density	1.52

3.1.4 Coarse Aggregate

Crushed stone, gravel, or a mix of the two make up conventional coarse aggregate. The crushed stone aggregate employed in this investigation will be well-graded and locally supplied, with particle sizes ranging from 10 - 20 mm. It is bought from a nearby supplier.

Table 3.4 The Properties of the Coarse Aggregate (Rafat Siddique et al., 2014)

S/N	Property	Value
1	Density	1.41
2	Crushed / uncrushed	Uncrushed
3	Maximum size of aggregate	20mm

3.1.5 Water

The study's water will be pure, drinkable, and devoid of any pollutants or impurities. To ensure uniformity in the mix design, the amount of water used in each mix will be determined by calculating the desired water-to-cement ratio. The University of Benin's Civil/Structural Engineering Laboratory provided the water for this experiment.

3.1.6 Oil/Grease

Concrete molds, also known as concrete cube cavities, will be lubricated with grease so that the concrete could be readily removed from them once it had formed. In order to minimize damage to the newly laid concrete specimen, it will be also used to lubricate the cone during the slump test.

3.2 Sample Preparation

Cow bone will be obtained from the abattoir in. New Benin. The cow bones will be sun dried after careful separation from flesh, tissues and fats. The ash will be carried out by incinerating the bone at a temperature of 900℃ in a furnace. Only the organic matter will be destroyed leaving a white mass of bone salt.

Sugar cane shaft ash, Groundnut shell ash will be obtained by burning groundnut shells on an iron sheet in the open air under normal temperature. The idea of burning them in furnace will be dropped because it will be time consuming and uneconomical for most people especially those that at the rural levels. The ash will be packed in polythene bags to prevent water absorption and for water proofing and stored in a cool dry place.

Concrete specimens will be formed for multiple testing using cubic molds with dimensions of 100 mm × 100 mm × 100 mm. In order to stop concrete from adhering to the mold surfaces, the molds will be cleaned and lubricated. The molds will be subsequently put together, and the bolts will be tightened to stop cement paste leaks. Concrete will be layered three times into the molds, and each time, the concrete will be fully compressed without segregation by vibrating the layer to release any trapped air. Then, a trowel will be used to complete surface polishing. After that, the test specimen will be sealed off from shock, vibration, and dehydration and left in molds for a whole day. Three cubes will be made for each blend in order to guarantee consistency and dependability of the outcomes.

3.2.1 Machines and Equipment Used During the Tests

The apparatus, machinery, and tools employed in this investigation include

1) concrete mixer
2) Compression testing machine
3) Vibrating machine
4) Weighing machine
5) Oven
6) Shovel
7) A set of British Standard (BS) sieves
8) Head pans
9) Curing Tank
10) Tamping rod
11) Measuring tape
12) Slump Cone
13) Measuring cylinder
14) Hand trowel.
15) Concrete molds
16) Head pan

3.2.2 Experimental Mix Design

A key step in the production of concrete technology is mix design, which is figuring out how much of each ingredient to add to get the right mix composition and performance.

Its goal is to produce a concrete mix that satisfies the needs for a particular building project, including strength, durability, workability, and other requirements.

To determine the quantity of materials needed to cast each cube specimen, a mix design for grade 25 concrete will be completed. The materials obtained have a ratio of 1:1.6:4.4, with the slump range chosen falling between 10 and 30 mm in accordance with BS 882 requirements.

3.2.2.1 Mix Design for C25 Grade Concrete

Cement content = 320 Kg/m^3 of cement

The workability level =10-30mm, FM=2.6, w/c=0.5, MSA=20 mm

The percentage of fine aggregates = 27%.

Fine aggregate content = 1920×0.27 = 515 Kg/m^3

Coarse aggregate content = 1920 – 515 = 1405Kg/m^3

3.2.3 Mix Proportions

13 major concrete mixes in total will be made:

1. control mix (0% replacement)
2. 5% replacement
3. 10% replacement
4. 15% replacement
5. Combination of the Three Admixtures

In order to provide an equitable comparison, the mix proportions will be created to keep the water-to-cement ratio at (0.5) for every combination. In accordance with ASTM C192, the particular mix design will be based on the absolute volume approach.

3.2.4 Curing

An essential component in developing concrete specimens is proper curing. Standard curing conditions will be applied to the concrete specimens in order to guarantee uniform curing for every sample. In order to achieve this, the specimens had to be placed in a damp atmosphere with wet burlap and Admixture sheeting to keep the humidity high, limit moisture loss, and encourage the cement to hydrate as best it could. To rule out curing as a factor influencing the outcomes, the curing time will be the same for all specimen.

For the purpose of evaluating the growth of strength, concrete specimen will be cured for varying amounts of time under specific circumstances (such as room temperature). Cubes will be cured for 7,14, and 28days at room temperature.

3.3 Particle Size Distribution

3.3.1 Sieve Analysis

In this test, a substance is divided into many particle size classifications of decreasing sizes using a succession of test sieves. The starting mass of the material is connected to the mass of the particle retained on the different sieves. Both numerical and graphical data are provided regarding the proportions of each sieve that pass through. The purpose of the test will be to ascertain the coarse aggregate's (granite) particle size distribution in accordance with (BS EN 993-1-1997).

3.3.1.2 Apparatus

The apparatus used include:

i. A set of British Standard sieve

ii. Weighing balance

iii. cleaning brush

iv. Scoop

v. Pan

3.3.1.3 Procedure

An accurately measured sample is placed onto the uppermost sieve with the largest screen opening. The lower sieve has narrower apertures compared to the ones positioned above it. 2. The recipient was situated at the foundation. 3. The sieve column was thereafter agitated for a predetermined duration. 4. The quantity of material that remained on each sieve was measured by weighing it. 5. The mass was thereafter divided by the total mass in order to calculate the percentage that remained on each sieve.

3.3.2 Aggregate Impact Value (AIV) Test

AIV assesses the ability of aggregates to withstand abrupt shocks or impacts and furnishes data on the resilience and impact tolerance of aggregates.

3.3.2.1 Apparatus

1. Impact Testing Machine
2. Cylindrical Steel Cup (diameter of at least 102 mm and a depth of at least 50 mm)
3. Metal Measure (75 mm diameter and 50 mm depth)
4. Tamping Rod

3.3.2.2 Procedures

1. Prepare a sample of aggregate that is retained on the 10 mm sieve after passing through the 14 mm screen.
2. Ensure a consistent layer of aggregate sample by placing it in the cylindrical cup.
3. With twenty-five strokes of the tamping rod, compact the aggregate.
4. Secure the cup tightly in the apparatus and deliver 15 consistent blows.
5. Expel the crushed material from the cup following the test.

6. Calculate the aggregate impact value (AIV) using the formula:

$$AIV=\frac{\text{Weight of Aggregates Passing 2.36 mm Sieve after Test}}{\text{Original Weight of Aggregates}}\times 100 \quad (3.2)$$

Stronger aggregates are indicated by a lower AIV.

3.3.3 Aggregate Crushing Value (ACV) Test

ACV evaluates aggregates' resistance to crushing under compressive loads and aids with quality control in the concrete manufacturing process by confirming that the aggregates are strong enough.

3.3.3.1 Apparatus

1. A 150mm BS Sieve
2. Cylindrical Metal Measure (115 mm diameter and 180 mm height)
3. Tamping Rod
4. Weighing Balance

3.3.3.2 Procedures

1. Get an aggregate sample that is retained on the 10 mm sieve after passing through the 12.5 mm sieve.
2. Three layers of aggregate should be added to the cylindrical measure, with each layer receiving 25 strokes from the tamping rod.
3. Weigh the cylindrical measure with the aggregate after tamping.
4. Pass the crushed aggregate through an BS sieve measuring 2.36 mm.
5. Calculate the aggregate crushing value (ACV) using the formula:

$$ACV=\frac{\text{Weight of Fines}}{\text{Weight of Aggregates}}\times 100 \quad (3.3)$$

Lower ACV indicates higher crushing strength of aggregates.

3.3.4 Slump Test

The purpose of the concrete slump test is to evaluate the consistency or workability of concrete mix that has been created in a laboratory using (BS 1881-102:1983).

3.3.4.1 Apparatus

The apparatus used include:

a. Slump cone: Shaped like the frustrum of a cone, with a height of 300 mm, a bottom diameter of 200 mm, and a top diameter of 100 mm.

b. Base plate

c. Measuring tape

d. Tamping rod

3.3.4.2 Procedures

1. Make sure that the interior surface of the slump cone is dry, clean, and clear of any cement residue that has set.
2. lubricate its interior surface with oil/grease to stop the slump cone from sticking and for easy removal
3. Make sure the slump cone is securely positioned by placing it on a square metal base plate.
4. Stabilize the cone by placing its metal arms on the base plate.
5. Place three layers of freshly mixed concrete within the slump cone, each about a quarter of the cone's height.
6. Make sure the strokes are uniformly distributed throughout the cross-section by tamping the concrete 25 times with a tamping rod after each layer.
7. After the third layer has been compacted evenly, start filling the cone with new concrete until it is full, letting the extra concrete spill over.
8. Make sure the surplus concrete is removed by using a trowel to remove it.

9. While the cone is still being held in place, clean the base plate and the bottom of the cone, removing any remaining concrete.
10. Raise the slump cone vertically from the newly laid concrete and set it gently next to the concrete.
11. For measuring and recording purposes, place the tamping rod atop the cone and align it with the concrete mound's height.
12. A measuring tape will be used to determine the slump, which is the difference between the cone's height and the height of the concrete specimen.

3.3.5 Compressive Strength Test

Compressive strength testing is a key test for determining how well concrete can support loads. A compression testing apparatus will be utilized in the process. Cubic samples will be examined after 3, 7,14, 21, and 28days of cure for every mixture. This made evaluating the strength development over time and contrasting the concrete with the control mix that had Admixtures substituted in it.

3.3.5.1 Procedure

1. The cubes will be taken out of the curing tank at various stages of curing.
2. The cubes will be then left to dry for about an hour on a platform.
3. The concrete cubes' weight is ascertained using a weighing balance.
4. The cubes will be placed so that the base plate of the compression machine will be in the center. The equipment is activated and measurements are obtained as soon as the specimen fails.

$$\text{Compressive Strength (N/ mm}^2\text{)} = \frac{\text{Maximum Load (KN)}}{\text{Cross Sectional Area (mm}^2\text{)}} \quad (3.4)$$

3.4 Mixing of Concrete

Mixing the materials will be done manually on a flat smooth and non-absorbent surface firstly, the sand will be spread in a uniform thickness and subsequent mixed with cement and some percentage if Groundnut shell ash (GSA) and Cow bone ash (CBA) and Sugar Cane Shaft Ash will be mixed thoroughly (5%, 10%, and 15% respectively), this is done separately for each admixture and then for the combination of the three. Then coarse aggregate will be spread on it, water will be added and the materials will be mixed vigorously and a homogeneous mixture will be achieved. A normally mix proportion of 1:1.6:4.4 (i.e., 1 part of cement: 2 parts of fine aggregate: 5 parts of coarse aggregate.) will be used. The cubes will be cast with water cement ratio of 0.5 and granite of 20mm size for the experiment.

3.5 Laboratory Tests

3.5.1 Sieve Analysis

The standard grain size analysis test determines the relative proportions of different grain sizes as they are distributed among certain size ranges.

3.5.1.1 Apparatus Required

1. Stack of sieve including pan and cover
2. Weighing balance (with accuracy to 0.01g)
3. Admixture and mortar (for crushing the soil if liquid or conglomerated)
4. Mechanical sieve shaker
5. Oven

3.5.1.2 Test Procedure

Take a representative oven dried sample or soil that weighs about 500g. If soil particles are lumped or conglomerated crush the lumped and not the particles using the pestle and mortar. Determine the mass of sample accurately Wt. in g.

1. Prepare a stack of sieves (i.e set of sieves), sieves having larger opening sizes are placed above the ones having smaller opening sizes.
2. Make sure sieves are clean, if many soil particles are stuck in the openings try to poke them out using brush.
3. Weigh all sieve and the pan separately
4. Pour the soil from steps into the stack in the sieve shaker and fix the clamps, adjust the time on 10 to 15 and get the shaker going.
5. Stop the sieve shaker and measure the mass of each sieve retained soil.
6. Tabulate your reading and complete the table.
7. Draw graph of log sieve size against % passing. The graph is known as grading curve.

Corresponding to 10%, 30% and 60% passing, obtain diameters from graph. These are D_{10}, D30 and D_{60}. Using these to obtain Cu and Cc which further represent how will the soil is graded i.e., whether the soil is well graded, gap graded or priory graded.

3.6 Slump Test

Slump Test is used to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. The slump test is the simplest workability test for concrete, involves low cost and provides immediate results. Due to this fact it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in (EN12350 – 2) in Eurocode.

Generally concrete slump value is used to find the workability which indicates water cement ratio but there are various factors like properties of materials, mixing methods, dosage, admixtures etc. which affect the concrete slump value.

James (1988) the concrete slump test is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch fresh made concrete. Consistency is term very closely related to workability. It is a term which describes the state of fresh concrete. it refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e., wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches.

The test is popular due to its simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the matter that the test is performed. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions and to ascertain the effects of Admixture on their introduction. This test is done to:

1. To check the consistency of the concrete,
2. To determine if the concrete flow smoothly into the shape of the formwork,
3. It is a quick check to see if the concrete is suitable for use.

3.6.1 Equipment Required

Mould for slump test, non porous base plate, measuring scale, tamping rod. The mould for the test is the form of the frustum of a cone having height 30cm (300mm), bottom diameter 20cm (200mm) and top diameter 10cm (100mm). The tamping rod is of steel 16mm diameter and 60cm (600mm) long and rounded at one end.

3.6.2 Procedure for Slump Test

1. Clean the internal surface of the mould and apply oil.
2. Place the mould on a smooth horizontal non – porous base plate
3. Fill the mould with the prepared concrete mix in 4 approximately equal layers
4. Tamp each layer with 25 stokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequently layers, the tamping should penetrate into the underlying layer.
5. Remove the excess concrete and level the surface with a trowel.
6. Clean away the mortar or water leaked out between the mould and the base plate.
7. Raise the mould from the concrete slowly in vertical direction.
8. Measure the slump as the difference between the height of the mould and that of highest point of the specimen being tested.

Note: The above operation should be carried out at a place free from vibrations or shock and within a period of 2 minutes after sampling.

3.6.3 Slump Value observation

The slump (vertical settlement) measured shall be recorded in terms of mm at subsidence of the specimen during the test.

When the slump test is carried out, following are the shape of the concrete slump that can be observed.

1. True Slump: It is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed as shown above

2. Zero Slump: It is the indication of very low water cement ratio, which results in dry mixes. This type of concrete is generally used for road construction
3. Collapsed Slump: It is an indication that the water – cement ratio is too high i.e., concrete mix is too wet or it is a high workability mix, for which a slump test is not appropriate.
4. Shear Slump: It indicates that the result is incomplete, and concrete to be retested.

3.7 Curing of Cubes

Curing is the process of keeping fresh concrete wet or moist for some days so as to facilitate hydration of cement paste for the concrete to gain strength. Properties of concrete of have been discovered to improve with age as long as the conditions are favourable for continue hydration. The rate and degree of hydration of cement paste and consequently its strength is affected significantly by lack of proper curing because of slow formation of strength, this increase in strength producing hydrates in order to maintain concrete must be properly cured.

Curing is very important practical in concrete technology in order for the concrete to achieve the required strength. After curing the cubes for 14, and 28days, the specimens will be removed from water and compressive strength test will be carried out.

3.8 Compressive Strength Test on Concrete Cubes

Out of many tests applied to the concrete, this is the most important which gives idea about all the characteristic of concrete. By this single test one can judge whether concreting has been done properly or not. To carryout cube test specimens mould size 100mmx100mmx100mm depending upon the size of aggregate to be used.

The concrete is poured in the mould and vibrated properly with the aid of the vibrating machine so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on the whole area of the specimen.

The specimens are tested by compression testing machine after 7, 14 days or 28 days curing. Load should apply gradually at the rate of 140kg/cm^2 the failure divided by area of specimen gives the compressive strength off concrete. Using the mathematical expression in (eqn 3.1 or eqn 3.4) compressive strength test will be carried out after adequate curing procedure will be fulfilled. This will be done in a manually operated hydraulic crushing machine. It consists of various parts like;

1. The base on which the specimen would be placed.
2. Handle for adjusting the steel plate of the machine and
3. The scale which indicates the readings corresponding to the failure load of the specimen.

3.8.1 Procedures for Compressive Strength Test

The concrete cube will be positioned on the base and at right angle to the adjacent steel plate during the crushing process. The handle is being adjusted continuously applying the load at constant rate. The scale of the machine consists of red and black which rises simultaneously as the load is being applied until a point is reached where the black pointer drops, at that point, cracks are observed. Generally, as a result of induced stress in the specimen via the ultimate compressive force applied and the load failure for each cube will be recorded according to the scale. By ascertaining the load failure and the surface area, the concrete strength can be obtained. However, the ultimate applied force depends on the specimens age, the type of materials used, the mixing proportion and the amount of water added.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results obtained from each of the tests carried out during the course of this study are shown in this chapter. Graphs and charts are also included where necessary to show how each of the percentage replacement aggregates performed relative to another.

The tests carried out include:

(i) Particle size distribution

(ii) Aggregate impact value test

(iii) Aggregate crushing value test

(iv) Slump test

(v) Compressive strength

4.1 Mix Design for C25 Grade Concrete

Descriptions of the mix:

1. Characteristic compressive strength of 25 N/mm^2 after 28 days
2. 5 % Defective
3. Cement: class 42.5
4. Slump required, 10-30 mm
5. Maximum free-water/Cement ratio 0.55
6. Minimum cement content 290 kg/m
7. Coarse aggregate: uncrushed single sized 20mm
8. Fine aggregate: Uncrushed with 90% passing 600 µm sieve
9. Relative density of aggregate: 2.6 (assumed)
10. Volume of trial mix: 0.001 m3

Step 01: Calculations for The Target Mean Strength

Target mean strength = $\mathbf{f_m}$

Specified characteristic strength = $\mathbf{f_c}$, Margin = $\boldsymbol{k.\ s}$

The standard deviation is 8 Mpa (figure 1) Specified characteristic strength is 25N/mm^2

k for 5% defectives = 1.64

$\boldsymbol{fm} = \boldsymbol{fc} + \boldsymbol{k.\ s}$

$\boldsymbol{fm} = 25 + 1.64 \times 8 = 38.12$ Mpa

Step 02: Calculation of Water/Cement Ratio

the compressive strength for w/c =0.50 is 42 MPa.

Step 03: Calculation of free Water Content

From Table 3.2, for 10-30 mm level of workability, crushed aggregates and maximum aggregate size of 20mm the water content is 160 kg/m3 concrete

Step 04: Calculation of cement Content

Water/cement Ratio = 0.5

Cement content = 160 ÷ 0.5

= 320 Kg/m^3 of cement

Step 05: Weight of Total Aggregates

From Figure 3.2 for free water content of 160 kg/m3, Specific gravity of uncrushed aggregates =2.6(assumed), the wet density of concrete = 2400 Kg/m^3. Therefore, the total aggregate content is

Total aggregate content = Wet density of 1m3 concrete – water content – cement content = 2400 – 160 – 320 = 1920 Kg/m^3

Step 06: Weight of Fine Aggregate

The workability level =10-30mm, FM=2.6, w/c=0.5, MSA=20 mm

The percentage of fine aggregates = 27%.

Fine aggregate content = 1920×0.27 = 515 Kg/m^3

Coarse aggregate content = 1920 – 515 = 1405Kg/m^3

4.2 AIV and ACV Test

4.2.1 AIV Test Results

<u>TEST A</u>

Mass of aggregate used= 327.5g

Mass of aggregate passing 2.36mm sieve = 113.5g

Mass of aggregate retained in 2.36mm sieve = 213.15g

AIV = $\frac{\text{Mass of aggregate passing 2.36mm sieve}}{\text{Mass of aggregate retained in 2.36mm sieve}} \times 100$

$= \frac{113.5}{327.5} \times 100$

= 34.66

<u>TEST B</u>

Mass of aggregate used= 331.30g

Mass of aggregate passing 2.36mm sieve = 101.3g

Mass of aggregate retained in 2.36mm sieve = 229.85g

AIV = $\frac{\text{Mass of aggregate passing 2.36mm sieve}}{\text{Mass of aggregate retained in 2.36mm sieve}} \times 100$

$= \frac{101.3}{331.3} \times 100$

= 30.58

Average AIV = $\frac{\text{TEST A+TEST B}}{2}$

$= \frac{34.66+30.58}{2}$

=32.62

Table 4.1: AIV result interpretation

AIV	CLASSIFICATION
< 10%	Exceptionally Strong
10 – 20%	Strong
20- 30%	Satisfactory for road surfacing
>35%	Weak for road surfacing

CHECK

Average Mass of aggregate used = $\frac{327.5+331.3}{2}$

=329.4

10% of 329.4 = 32.94

Since **32.94 < 32.62** (Average AIV value)

Hence AIV is <10% (EXCEPTIONALLY STRONG)

4.2.2 ACV TEST RESULTS

TEST A

Mass of aggregate used= 2784g

Mass of aggregate passing 2.36mm sieve = 806.9g

Mass of aggregate retained in 2.36mm sieve = 1976.3g

AIV = $\frac{\text{Mass of aggregate passing 2.36mm sieve}}{\text{Mass of aggregate retained in 2.36mm sieve}} \times 100$

$= \frac{806.9}{2784} \times 100$

= 28.983

<u>TEST B</u>

Mass of aggregate used= 2735g

Mass of aggregate passing 2.36mm sieve = 805.5g

Mass of aggregate retained in 2.36mm sieve = 1929g

AIV = $\frac{\text{Mass of aggregate passing 2.36mm sieve}}{\text{Mass of aggregate retained in 2.36mm sieve}} \times 100$

$= \frac{805.5}{2735} \times 100$

= 29.452

Average AIV = $\frac{\text{TEST A+TEST B}}{2}$

$= \frac{28.983+29.452}{2}$

=29.22

4.3 Sieve Analysis

4.3.1 Particle Size Distribution of Natural Fine Aggregates

The sieve analysis revealed the particle size distribution of natural fine aggregates. Figure 4.1a illustrates the particle size distribution of natural fine aggregates. Table 4.2a gives the result obtained from the sieve analysis of fine aggregate.

Table 4.2a: Result from Sieve Analysis for fine aggregate

Sieve Size (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
2.36	**0.79**	**0.79**	**0.55**	**99.45**
2.00	**0.46**	**0.46**	**1.25**	**98.75**
1.18	**2.93**	**2.93**	**4.18**	**95.82**
600	**16.73**	**16.73**	**20.91**	**79.09**
425	**21.17**	**21.17**	**42.08**	**57.92**
300	**12.4**	**12.4**	**54.48**	**45.52**
212	**40.16**	**40.16**	**94.64**	**5.36**
150	**1.75**	**1.75**	**96.39**	**3.61**
75	**2.88**	**2.88**	**99.27**	**0.73**
Pan	**0.3**	**0.3**	**99.57**	**0.43**

This particle size distribution curve suggests that the fine aggregate sample has a predominantly fine particle size distribution, with a relatively small number of coarser particles. This information is essential for concrete mix design, as it influences the workability, strength, and durability of concrete.

From table 4.2a, the sieve analysis results give a comprehensive overview of the particle size distribution within the fine aggregate sample. It discerns a spectrum of particle sizes, ranging from larger particles retained on the 2.36mm sieve, which constitutes 0.79% of the total mass, to finer particles passing through the 75mm sieve, representing 99.27% of the aggregate. This gradual transition from coarser to finer particles is evident in the cumulative percentage retained and passing values, illustrating a consistent reduction in retained mass and an increase in passing percentage as the sieve size decreases. For instance, at the 2.36mm sieve, the cumulative percentage retained stands at 0.55%, while the corresponding cumulative percentage passing is 99.45%, indicative of a well-graded aggregate composition. Furthermore, the total mass of the sand tested, quantified at 100.00 g, aligns precisely with the sum of the masses retained on all sieves and the pan, affirming the accuracy and completeness of the analysis.

Total Mass of sand tested = 100.00g $\qquad\qquad$ $\sum F = 486.68$

Fineness Modulus = $\frac{\sum F}{\text{Total Mass tested}} = \frac{486.68}{100} = 4.8668$

% Retained = $\frac{\text{Mass retained}}{\text{Total Mass tested}} \times 100$

Cumulative % Retained = % retained + the succeeding % retained

% passing = $100 -$ Cummulative % Retained

% loss < 0.5

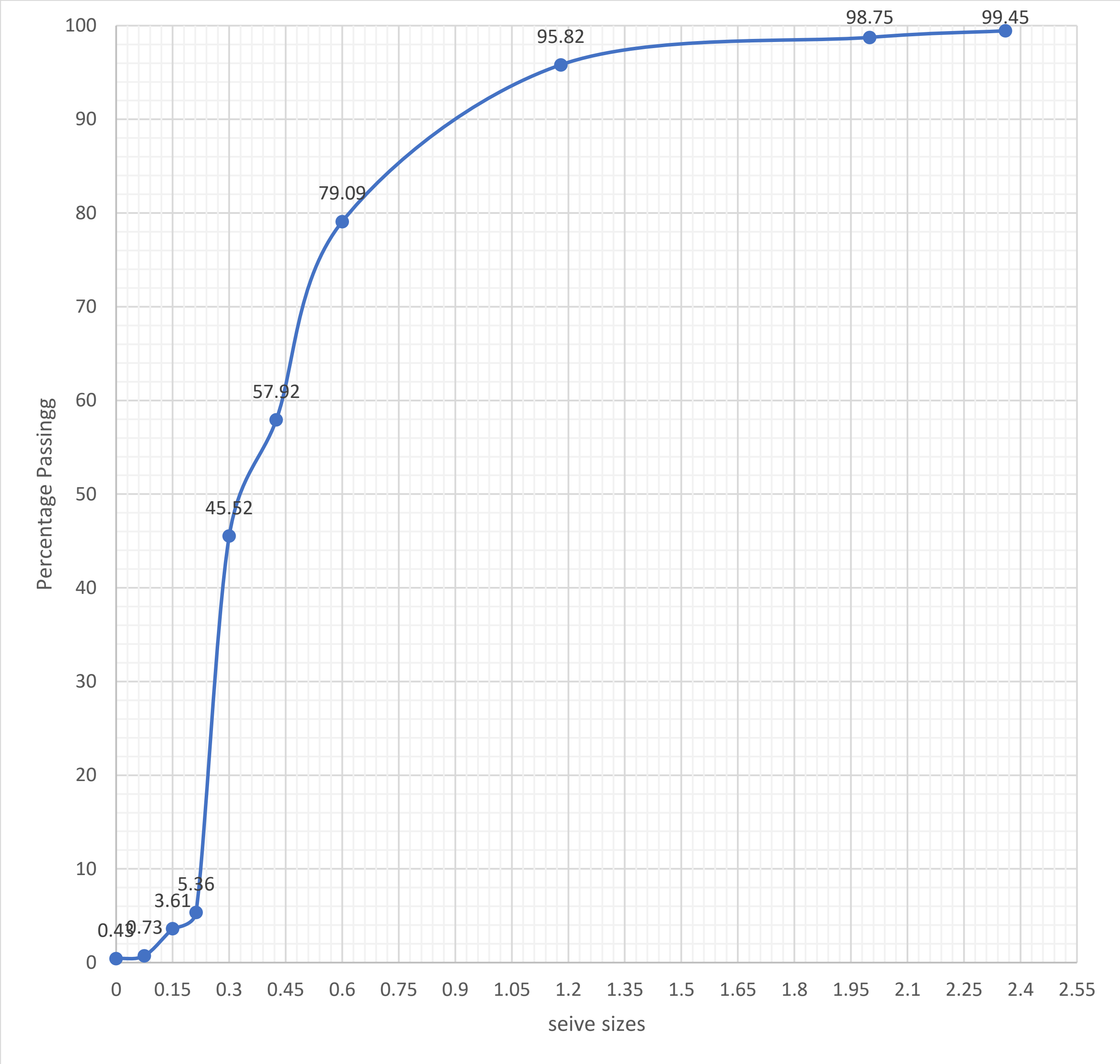


Fig 4.1 Showing Particle Distribution of the Natural Fine aggregate

4.3.2 Particle Size Distribution of Admixtures

The sieve analysis revealed the particle size distribution of admixtures used. This information is essential for understanding how the fine aggregate compares to admixture. Figure 4.2 illustrates the particle size distribution of the admixtures used. Table 4.2b gives the result obtained from the sieve analysis of fine aggregate.

Table 4.2b: Result of Sieve Analysis for the Admixture

Total Mass Tested = 100 g

Sieve Size(mm)	Mass Retained(g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
2.36	0.60	1.26	0.11	96.21
2.00	0.18	0.15	2.71	94.22
1.18	6.53	6.627	9.408	90.59
600	31.19	31.66	41.068	58.93
425	18.68	18.96	60.028	39.97
300	22.58	22.92	82.948	17.05
212	11.87	12.05	94.998	5.00
150	0.68	0.69	95.688	4.31
75	1.50	1.52	97.208	2.79
Pan	1.25	0.269	95.477	1.52

From table 4.2b, the sieve analysis results provide a comprehensive insight into the particle size distribution of the fine aggregate sample. Starting with the coarsest sieve size of 2.36mm, 1.26% of the aggregate mass is retained, with 96.21% passing through. As the sieve sizes decrease, there is a gradual increase in the percentage retained and a corresponding decrease in the percentage passing, reflecting the transition to finer particles. Notably, at the 600mm sieve, 31.66% of the aggregate mass is retained, contributing to a cumulative percentage retained of 41.068%, while 58.93% passes through. This trend continues, with the cumulative percentage retained reaching 94.998% at the 212mm sieve, indicating predominantly finer particles in the sample. The total mass retained on all sieves and the pan sums up to 99.731 g, affirming the completeness of the analysis. These findings suggest a well-graded aggregate with a balanced distribution of particle sizes, which is essential for achieving optimal concrete mix designs and ensuring the desired mechanical properties in construction applications.

% Retained = $\frac{\textbf{Mass retained}}{\textbf{Total Mass tested}} \times \mathbf{100}$

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

Discussion of the Results obtained from the Sieve Analysis

From fig 4.1 and 4.2, the particle distributions of the fine aggregate and the Admixture have a very similar textural profile, hence, they are compatible for comparison.

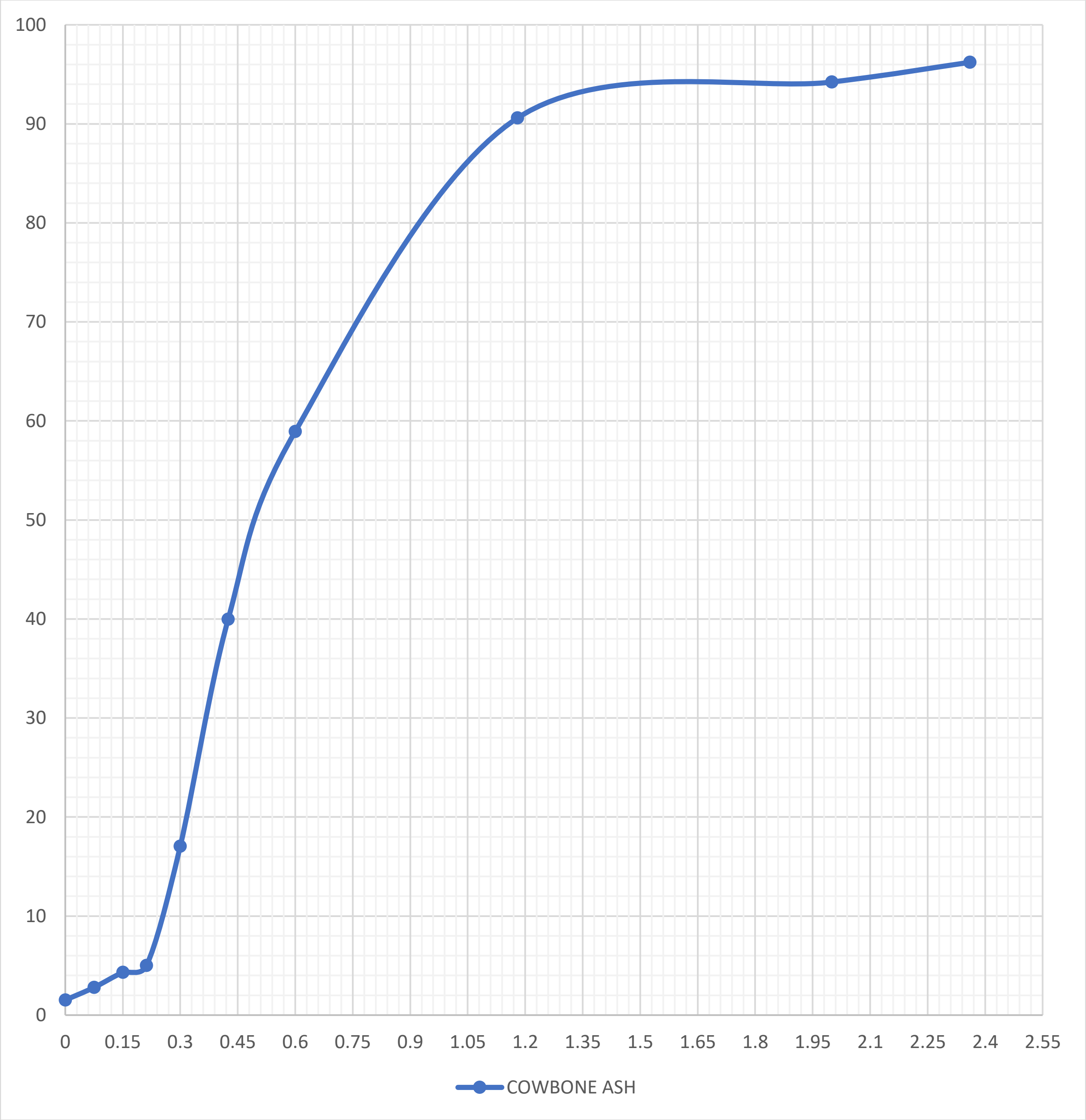


Fig 4.2: Particle Distribution for the Cow Bone Ash

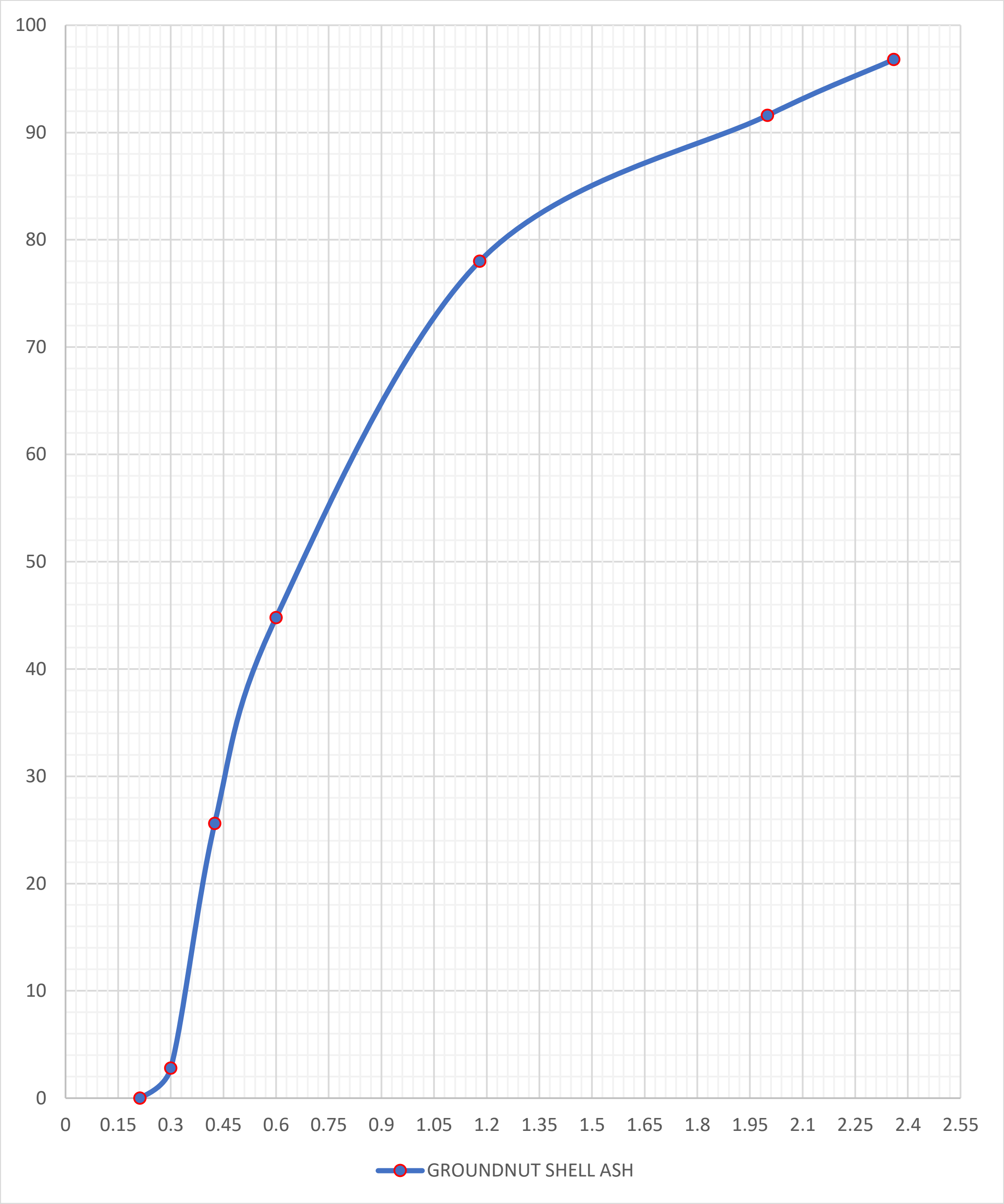


Fig 4.3: Particle Distribution for the Groundnut shell Ash

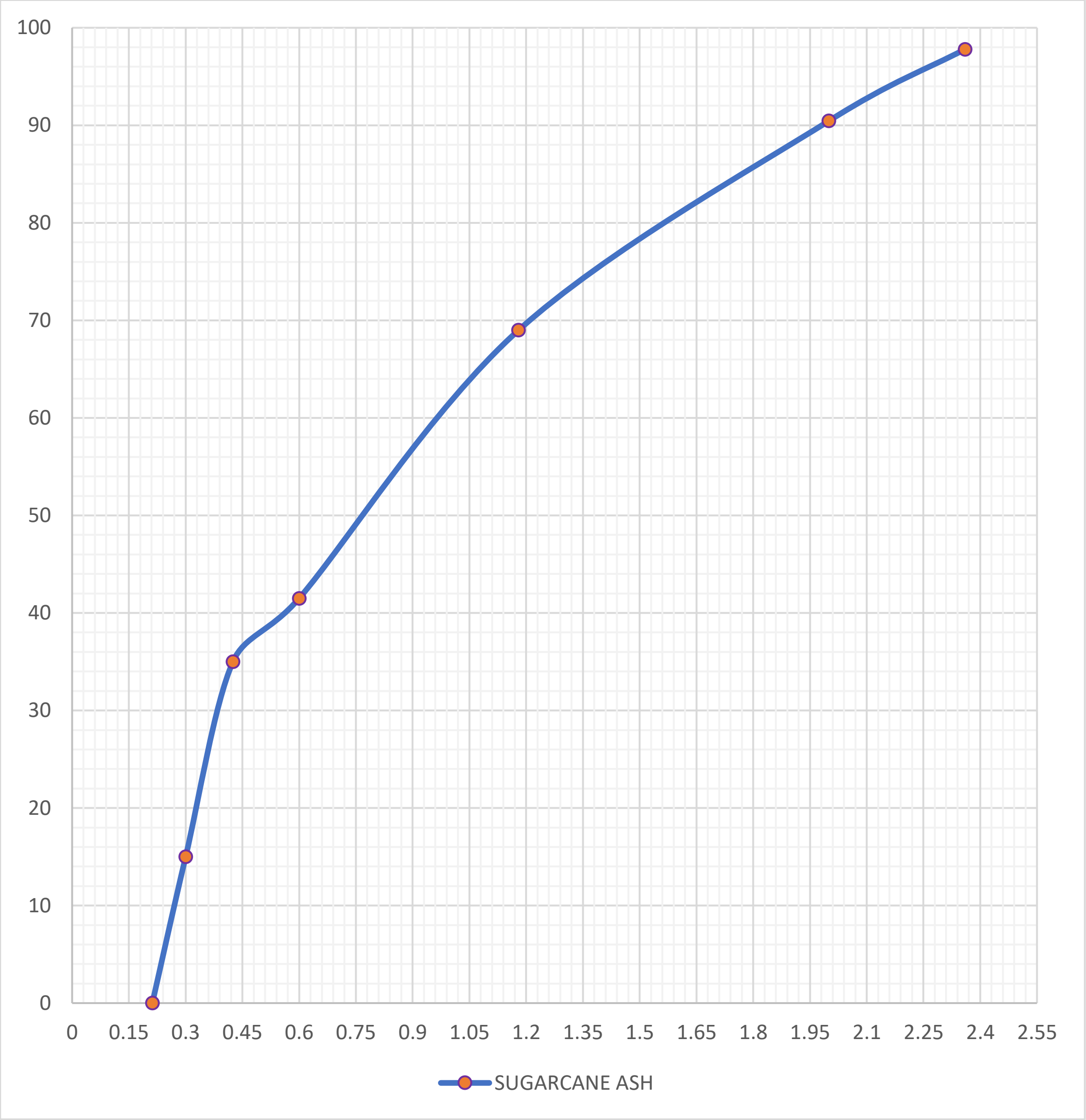


Fig 4.4: Particle Distribution for the Sugarcane Ash

4.4 Results from Slump Test

The slump test is used to evaluate the workability or consistency of the concrete mixes. The results of the slump tests conducted on each mix, including the control and admixture-replaced mixes, are presented in Table 4.3.

Table 4.3: Results from Slump Test

Sample No	Slump 1 (mm)	Slump 2 (mm)	Slump 3 (mm)	Average Slump (mm)
0% (CONTROL)	10	10	12	10.67
5% REPLACEMENT	13	11	14	12.67
10% REPLACEMENT	15	13	15	14.33
15% REPLACEMENT	19	18	19	18.67

From table 4.3, the control sample, with 0% replacement, exhibits an average slump of 10.67 mm, indicative of its consistency and workability. As the replacement percentage increases, there is a noticeable increase in the average slump values. For instance, with 5% replacement, the average slump rises to 12.67 mm, indicating a slight improvement in workability. This trend continues with 10% replacement resulting in an average slump of 14.33 mm, and 15% replacement yielding the highest average slump of 18.67 mm. These results suggest that as the percentage of replacement increases, the workability of the concrete also increases, likely due to changes in the material properties and its interaction with the concrete mix. However, it's important to consider other factors such as strength and durability when determining the optimal replacement percentage for practical applications in construction.

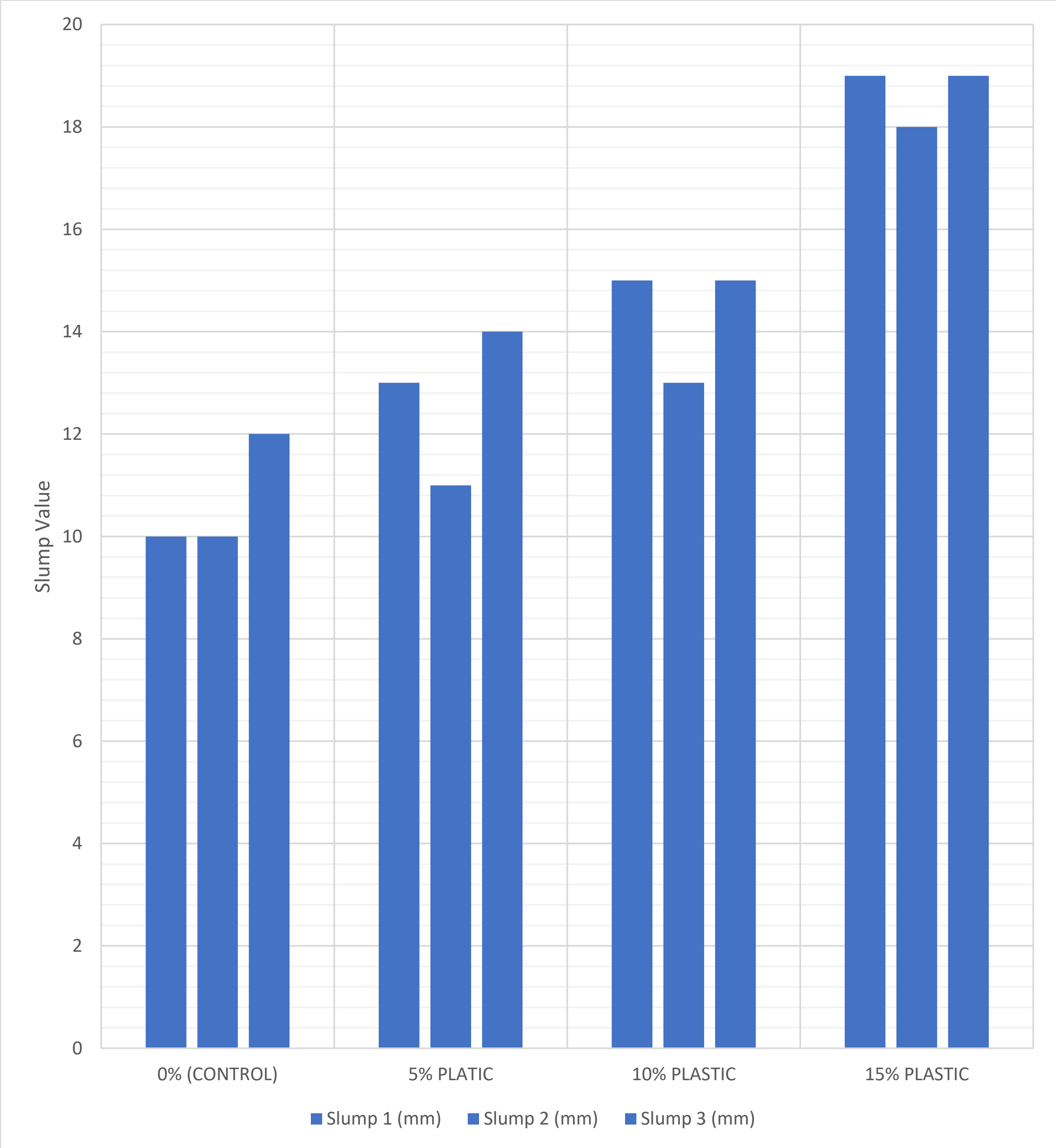


Fig 4.5 showing the variation of the slump with % increase in replacement

Fig 4.2 shows that the slump of the fresh concrete decreased with increase in the replacement of the fine aggregate. This implies that the presence of Admixture in the concrete decreased its workability. However, the average slump values shows that all the replacement percentages passed the slump test which is expected to range between 10mm to 30mm for the designed concrete grade (C25).

4.5 COMPRESSIVE STRENGTH TEST

The primary focus of this study was the assessment of compressive strength. Once the curing period was completed, the concrete specimens were subjected to compressive strength testing. This testing was conducted using a hydraulic compression testing machine. Each specimen was carefully placed between the platens of the compression testing machine. Care was taken to ensure that the load was evenly distributed across the specimen. A gradual and continuous load was applied to the specimen until it failed. The load at failure, along with the dimensions of the specimen, was recorded.

Following the test, the recorded data serves as the basis for calculating the compressive strength of the concrete specimen.

This calculation is performed by dividing the maximum applied load by the specimen's cross-sectional area.

4.5.1 Result from Compression Test

The tables below show the results from the compression tests for the various samples

Table 4.4: Result for Compression Test for Control mix (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.577**	**2577**	**190**	**19**	2563.67	**19**
	M_2	**2.61**	**2610**	**210**	**21**		
	M_3	**2.504**	**2504**	**170**	**17**		
14	M_1	**2.623**	**2623**	**165.03**	**16.503**	2622.67	**19.128**
	M_2	**2.634**	**2634**	**211.36**	**21.136**		

	M_3	**2.611**	**2611**	**177.44**	**19.744**		
28	M_1	**2.73**	**2730**	**250.03**	**25.003**	2731.67	**24.697**
	M_2	**2.695**	**2695**	**230.69**	**23.069**		
	M_3	**2.77**	**2770**	**260.18**	**26.018**		

7 Days: The average compressive strength ranges from 17 N/mm² to 21 N/mm², which meets the early strength requirements outlined in BS EN 206-1:2000 and BS 8500-1:2015 for standard concrete mixes. 14 Days: Achieves average strengths of approximately 19 N/mm² to 21 N/mm², indicating robust early development and suitability for load-bearing applications. 28 Days: Shows strengths averaging around 23 N/mm² to 26 N/mm², meeting or exceeding BS standards for durable concrete mixes suitable for structural applications.

Table 4.5 Result for compression test for 5% CBA (mix ratio 1:1.6:4.4)

No of Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.524**	**2524**	**200**	**20**	2550.67	**15.5**
	M_2	**2.493**	**2493**	**145**	**14.5**		
	M_{13}	**2.635**	**2635**	**120**	**12**		
14	M_1	**2.623**	**2623**	**114.76**	**11.476**	2626	**16.4**
	M_2	**2.649**	**2649**	**189.93**	**18.993**		

	M_3	**2.606**	**2606**	**187.32**	**18.732**		
28	M_1	**2.705**	**2705**	**190.35**	**19.035**	2702.67	**20.678**
	M_2	**2.619**	**2619**	**230.01**	**23.010**		
	M_3	**2.784**	**2784**	**199.89**	**19.989**		

From Table 4.5, at the 7 Day mark, the average strengths range from 12 N/mm² to 20 N/mm², demonstrating enhanced early strength compared to the control mix, suitable for rapid construction. In 14 Days, it achieves strengths of approximately 16 N/mm² to 19 N/mm², indicating continued development and potential durability improvements. Finally, at 28 Days, it shows strengths ranging from 18 N/mm² to 23 N/mm², suggesting long-term performance enhancements and potential cost savings in construction.

Table 4.6 Result for compression test for 5% GSA (mix ratio 1:1.6:4.4)

No of Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.514**	**2514**	**185.65**	18.565	2528.67	**14.7977**
	M_2	**2.509**	**2509**	**148.03**	14.803		
	M_{13}	**2.563**	**2563**	**110.25**	11.025		
14	M_1	**2.603**	**2603**	**114.77**	**11.477**	2587.67	**16.346**
	M_2	**2.551**	**2551**	**188.39**	**18.839**		

	M_3	**2.609**	**2609**	**187.22**	**18.722**		
28	M_1	**2.513**	**2513**	**189.55**	**18.955**	2518	**20.035**
	M_2	**2.501**	**2501**	**225.03**	**22.503**		
	M_3	**2.54**	**2540**	**186.48**	**18.648**		

From Table 4.6, at the 7 Day mark, the average strengths range from 11 N/mm² to 18 N/mm², showing varying degrees of early strength development suitable for different construction phases. By 14 Days, it demonstrates strengths of approximately 16 N/mm² to 19 N/mm², indicating further development and potential durability benefits. Finally, at 28 Days, it shows strengths ranging from 18 N/mm² to 20 N/mm², suggesting reliable long-term performance improvements over the control mix.

Table 4.7 Result for compression test for 5% SCA (mix ratio 1:1.6:4.4)

No of Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.562**	**2562**	**166.23**	16.623	2536.33	**14.7023**
	M_2	**2.518**	**2518**	**154.77**	15.477		
	M_{13}	**2.529**	**2529**	**120.07**	12.007		
14	M_1	**2.503**	**2503**	**114.76**	**11.476**	2536	**16.22**
	M_2	**2.515**	**2515**	**189.93**	**18.993**		

	M_3	**2.59**	**2590**	**187.32**	**18.732**		
28	M_1	**2.571**	**2571**	**189.05**	18.905	2638.67	**20.0187**
	M_2	**2.601**	**2601**	**215.03**	21.503		
	M_3	**2.744**	**2744**	**196.48**	19.648		

From Table 4.7, at the 7 Day mark, the average strengths range from 10 N/mm² to 16 N/mm², indicating early strength development suitable for rapid construction applications. By 14 Days, it achieves strengths of approximately 12 N/mm² to 18 N/mm², showing continued development and potential durability enhancements. Finally, at 28 Days, it shows strengths ranging from 13 N/mm² to 20 N/mm², demonstrating reliable long-term performance and durability improvements.

Table 4.8 Result for compression test for 10% CBA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.551**	**2551**	**140**	**14**	2478.33	**13.744**
	M_2	**2.477**	**2477**	**151.22**	**15.122**		
	M_3	**2.407**	**2407**	**121.09**	**12.109**		
14	M_1	**2.441**	**2441**	**178.58**	**17.858**	2510.33	
	M_2	**2.591**	**2591**	**162.25**	**16.225**		

	M_3	**2.499**	**2499**	**121.01**	**12.101**		**15.395**
28	M_1	**2.598**	**2598**	**191.23**	**19.123**	2580	**16.518**
	M_2	**2.565**	**2565**	**156.58**	**15.658**		
	M_3	**2.577**	**2577**	**147.74**	**14.774**		

From Table 4.8, at the 7 Day mark, the average strengths range from 9 N/mm² to 15 N/mm², indicating enhanced early strength development compared to lower admixture percentages. By 14 Days, it shows strengths of approximately 12 N/mm² to 17 N/mm², suggesting further development and potential cost-effectiveness in construction. Finally, at 28 Days, it demonstrates strengths ranging from 14 N/mm² to 19 N/mm², indicating durable long-term performance suitable for various structural applications.

Table 4.9 Result for compression test for 10% GSA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.556**	**2556**	**142.23**	**14.223**	2527.67	**13.344**
	M_2	**2.557**	**2557**	**155.12**	**15.512**		
	M_3	**2.47**	**2470**	**102.97**	**10.297**		
14	M_1	**2.457**	**2457**	**130.02**	**13.002**		

	M_2	**2.543**	**2543**	**174.28**	**17.428**	2507.33	**15.29**
	M_3	**2.522**	**2522**	**154.41**	**15.441**		
28	M_1	**2.426**	**2426**	**188.02**	**18.802**	2414.67	**16.262**
	M_2	**2.404**	**2404**	**173.85**	**17.385**		
	M_3	**2.414**	**2414**	**125.98**	**12.598**		

From Table 4.9, at the 7 Day mark, the average strengths range from 10 N/mm² to 15 N/mm², showing improved early strength development compared to lower admixture percentages. By 14 Days, it achieves strengths of approximately 12 N/mm² to 17 N/mm², indicating robust early development and potential durability benefits. Finally, at 28 Days, it shows strengths ranging from 12 N/mm² to 17 N/mm², suggesting reliable long-term performance enhancements over the control mix.

Table 4.10 Result for compression test for 10% SCA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.543**	**2543**	**138.84**	**13.884**	2536	**13.325**
	M_2	**2.538**	**2538**	**99.87**	**9.987**		
	M_3	**2.527**	**2527**	**161.03**	**16.103**		
14	M_1	**2.443**	**2443**	**141.97**	**14.197**		

	M_2	**2.508**	**2508**	**168.63**	**16.863**	2470.67	**15.362**
	M_3	**2.461**	**2461**	**150.26**	**15.026**		
28	M_1	**2.443**	**2443**	**188.48**	**18.848**	2437.67	**16.240**
	M_2	**2.442**	**2442**	**161.24**	**16.124**		
	M_3	**2.428**	**2428**	**137.47**	**13.747**		

From Table 4.10, at the 7 Day mark, the average strengths range from 9 N/mm² to 14 N/mm², indicating enhanced early strength development suitable for rapid construction. By 14 Days, it shows strengths of approximately 13 N/mm² to 17 N/mm², showing continued development and potential durability improvements. Finally, at 28 Days, it demonstrates strengths ranging from 13 N/mm² to 16 N/mm², suggesting reliable long-term performance and durability benefits.

Table 4.11 Result for compression test for 15% CBA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.386**	**2386**	**105.24**	**10.524**	2392	**10.989**
	M_2	**2.391**	**2391**	**121.84**	**12.184**		
	M_3	**2.399**	**2399**	**102.58**	**10.258**		
14	M_1	**2.464**	**2464**	**120.14**	**12.014**		

	M_2	**2.471**	**2471**	**133.26**	**13.326**	2465.67	**12.309**
	M_3	**2.462**	**2462**	**115.88**	**11.588**		
28	M_1	**2.351**	**2351**	**133.24**	**13.324**	2361.7	**14.763**
	M_2	**2.3501**	**2350.1**	**162.26**	**16.226**		
	M_3	**2.384**	**2384**	**147.38**	**14.738**		

From Table 4.11, at the 7 Day mark, the average strengths range from 10 N/mm² to 12 N/mm², showing notable early strength development suitable for specialized applications. By 14 Days, it achieves strengths of approximately 11 N/mm² to 13 N/mm², indicating further development and potential cost-effectiveness. Finally, at 28 Days, it shows strengths ranging from 13 N/mm² to 15 N/mm², demonstrating durable long-term performance and suitability for structural projects.

Table 4.12 Result for compression test for 15% GSA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.351**	**2351**	**131.24**	**13.124**	2361.7	**11.889**
	M_2	**2.3501**	**2350.1**	**122.84**	**12.284**		
	M_3	**2.384**	**2384**	**102.58**	**10.258**		
14	M_1	**2.355**	**2355**	**163.41**	**16.341**		

	M_2	**2.348**	**2348**	**123.42**	**12.342**	2356	**13.424**
	M_3	**2.365**	**2365**	**115.88**	**11.588**		
28	M_1	**2.315**	**2315**	**155.41**	**15.541**	2322.67	**14.424**
	M_2	**2.305**	**2305**	**148.42**	**14.842**		
	M_3	**2.348**	**2348**	**122.88**	**12.288**		

From Table 4.12, at the 7 Day mark, the average strengths range from 10 N/mm² to 13 N/mm², indicating enhanced early strength development suitable for rapid construction phases. By 14 Days, it shows strengths of approximately 11 N/mm² to 16 N/mm², showing continued development and potential durability improvements. Finally, at 28 Days, it demonstrates strengths ranging from 12 N/mm² to 15 N/mm², suggesting reliable long-term performance and durability benefits over the control mix.

Table 4.13 Result for compression test for 15% SCA (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	**2.356**	**2356**	**115.24**	**11.524**	2382.67	**10.722**
	M_2	**2.391**	**2391**	**103.84**	**10.384**		
	M_3	**2.401**	**2401**	**102.58**	**10.258**		
14	M_1	**2.408**	**2408**	**120.14**	**12.014**	2406	**12.512**
	M_2	**2.421**	**2421**	**123.26**	**12.326**		

	M_3	**2.389**	**2389**	**125.88**	**12.588**		
28	M_1	**2.507**	**2507**	**133.24**	**13.324**	2361.7	**14.763**
	M_2	**2.531**	**2531**	**162.26**	**16.226**		
	M_3	**2.513**	**2513**	**147.38**	**14.738**		

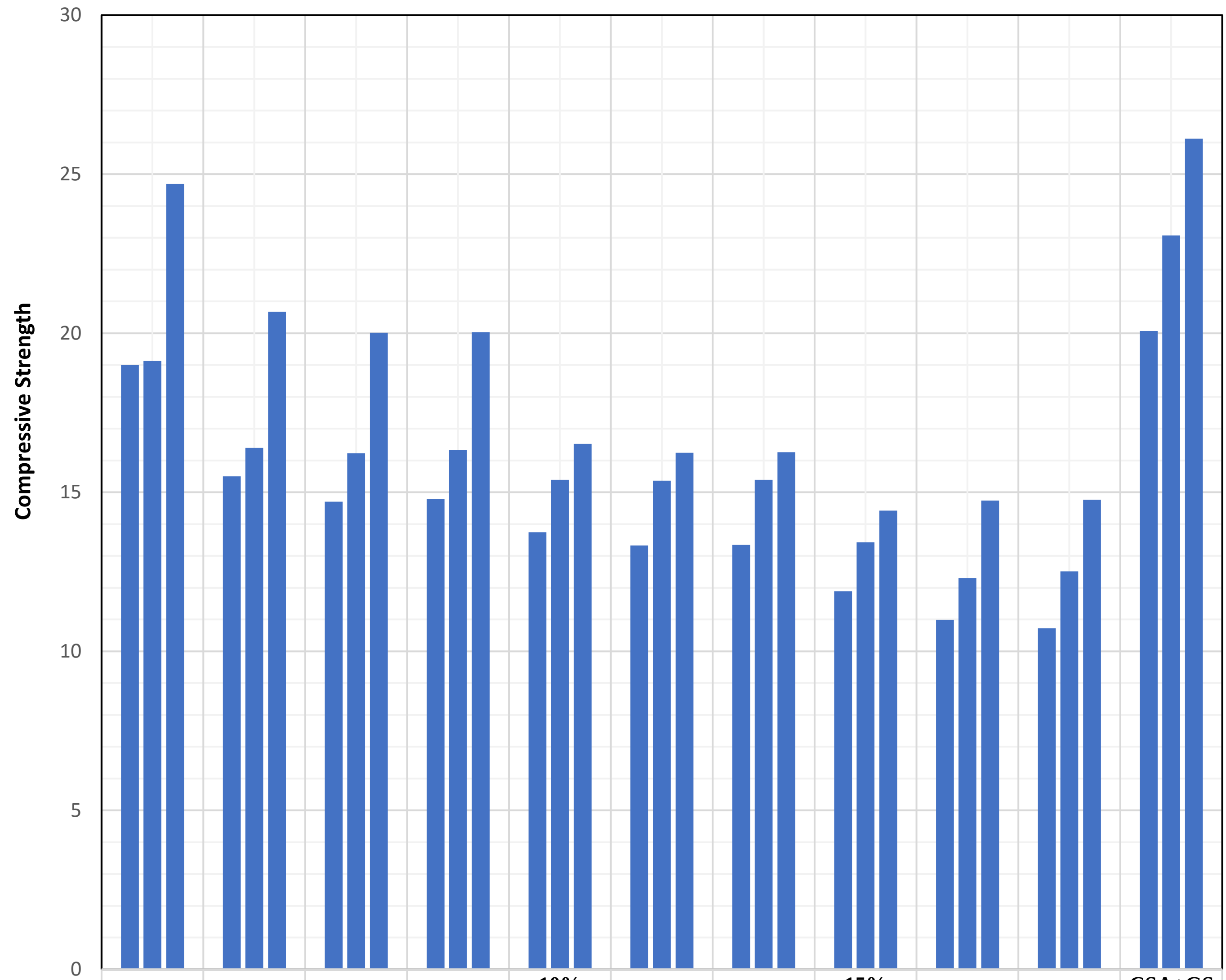
From Table 4.13, at the 7 Day mark, the average strengths range from 10 N/mm² to 12 N/mm², demonstrating robust early strength development suitable for rapid construction phases. By 14 Days, it achieves strengths of approximately 10 N/mm² to 13 N/mm², indicating continued development and potential durability enhancements. Finally, at 28 Days, it shows strengths ranging from 12 N/mm² to 14 N/mm², suggesting reliable long-term performance and durability improvements.

Table 4.14 Result for compression test for Combined Admixture (mix ratio 1:1.6:4.4)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7	M_1	2.510	2510	209.0	20.9	2531.0	20.07
	M_2	2.556	2556	194.0	19.4		
	M_3	2.527	2527	199.0	19.9		
14	M_1	2.512	2512	219.0	21.9		

	M_2	2.511	2511	237.0	23.7	2509	23.07
	M_3	2.504	2504	236.0	23.6		
28	M_1	2.532	2532	254.71	25.471	2532.7	26.116
	M_2	2.549	2549	277.54	27.754		
	M_3	2.517	2517	251.23	25.123		

From Table 4.14, at the 7 Day mark, the average strengths range from 19 N/mm² to 21 N/mm², indicating high early strength potential suitable for rapid construction and time-sensitive projects. By 14 Days, it demonstrates strengths of approximately 21 N/mm² to 24 N/mm², showing continued development and potential cost savings in construction. Finally, at 28 Days, it shows strengths ranging from 25 N/mm² to 27 N/mm², suggesting robust long-term performance and durability benefits compared to standard mixes.



	0%	5% CBA	5% GSA	5% SCA	10% CBA	10% GSA	10% SCA	15% CBA	15% GSA	15% SCA	CSA+GSA+SCA
7 DAYS	19	15.5	14.7023	14.797	13.744	13.325	13.344	11.889	10.989	10.722	20.07
14 DAYS	19.128	16.4	16.22	16.326	15.395	15.362	15.395	13.424	12.309	12.512	23.07
28 DAYS	24.697	20.678	20.0187	20.035	16.518	16.24	16.262	14.424	14.738	14.763	26.116

Fig 4.6 showing the average maximum strength obtained at various curing period for each percentage replacement

A seen the replacement with the combination of the three gave the highest percent.

From the results obtained and represented on fig 4.3, the average maximum strength was obtained when the fine aggregate was replaced by 15% with the Admixture. However, all other percentage replacement gave values that conform to the expected design characteristic design of the concrete (20 KN/mm^2).

Each table provides detailed results from compression tests conducted on concrete samples with different admixtures and curing durations. The tables include data on the weight of the samples, density of the sample cubes, failure load, and compressive strength, with averages calculated for each parameter. For instance, in Table 4.4, which presents results for 5% CBA (Grade 25) at various curing durations, sample M1 at 7 days had an average density of 2563.67 kg/m^3 and an average compressive strength of 19 N/mm^2, while at 28 days, the average density increased to 2731.67 kg/m^3, with an average compressive strength of 24.697 N/mm^2. Similarly, Table 4.7 showcases the results for combined admixtures, where sample M1 at 7 days had an average density of 2531.0 kg/m^3 and an average compressive strength of 20.07 N/mm^2, while at 28 days, the average density increased to 2532.7 kg/m^3, with an average compressive strength of 26.116 N/mm^2. These tables offer comprehensive insights into the effects of different admixtures and curing durations on the compressive strength and density of concrete samples, providing valuable data for evaluating their performance in construction applications.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 CONCLUSION

The case studies of sugar cane shaft ash, cow bone ash, and groundnut shell ash as admixtures in concrete have revealed their potential in enhancing various properties of concrete. These admixtures contribute to strength development, improve durability, and offer sustainable alternatives to conventional construction materials. The analysis of the results obtained from the compression tests, slump tests, and sieve analysis provides valuable insights into the performance and characteristics of concrete samples with different admixtures and replacement percentages. From the findings, it is evident that the combination of the three admixtures resulted in the highest percentage increase in compressive strength. Additionally, the average maximum strength was achieved when the fine aggregate was replaced by 15% with the admixture. Despite variations in replacement percentages, all samples exhibited compressive strengths that align with the expected design characteristics of concrete, particularly around the target value of 20 KN/mm^2. The sieve analysis further revealed a well-graded particle size distribution in the fine aggregate samples, indicating suitability for achieving optimal concrete mix designs. Overall, the results underscore the importance of carefully selecting admixtures and replacement percentages to enhance concrete performance while ensuring workability and particle size distribution consistency.

5.1 RECOMMENDATIONS

Further Research: Continued research is recommended to explore optimal mix proportions and curing conditions for concrete incorporating these admixtures, ensuring consistent performance across different applications and environmental conditions.

Field Trials: Conducting field trials and long-term monitoring of structures constructed using concrete with these admixtures can provide valuable insights into their real-world performance and durability.

Standardization: Collaboration with industry stakeholders and regulatory bodies is essential to establish standards and guidelines for the use of these admixtures in concrete production, ensuring quality control and structural integrity.

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APPENDIX